Canadian Aviation
Safety Board

Bureau canadien
de la sécurité aérienne

STAFF REPORT
ON
THE CASB's SPECIAL INVESTIGATION
INTO AIR TRAFFIC CONTROL SERVICES
IN CANADA

1 DECEMBER 1989

Canadä

STAFF REPORT
ON
THE CASB's SPECIAL INVESTIGATION
INTO AIR TRAFFIC CONTROL SERVICES
IN CANADA

1 DECEMBER 1989

Canada

©Minister of Supply and Services Canada 1990
Cat. No. TU 4-6/1990E
ISBN 0-662-17694-4
Ce rapport est également disponible en français

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

1. INTRODUCTION 1-1

1.1 BACKGROUND 1-1

1.2 AIM 1-4

1.3 SCOPE 1-4

1.4 CONDUCT OF SPECIAL INVESTIGATION 1-5

CHAPTER 2 THE ATS SYSTEM

2. INTRODUCTION 2-1

2.1 AIRSPACE STRUCTURE 2-1
- 2.1.1 Canadian Domestic Airspace: 2-1
- 2.1.2 Minimum Navigation Performance Specification Airspace 2-2
- 2.1.3 Flight Information Regions 2-3
- 2.1.4 Controlled Airspace 2-4
- 2.1.5 High Level Controlled Airspace 2-4
- 2.1.6 Low Level Airspace 2-5
- 2.1.7 Use of Controlled Airspace by VFR Aircraft . . . 2-5

2.2 ORGANIZATION OF CANADIAN AIR TRAFFIC SERVICES 2-6
- 2.2.1 General 2-6
- 2.2.2 Air Traffic Services Units 2-7

2.3 ATS ORGANIZATION WITHIN TRANSPORT CANADA 2-9

2.4 ACTIVITY RATES 2-14

2.5 SUMMARY 2-15

TABLE OF CONTENTS

CHAPTER 3 ANALYSIS OF CANADIAN INCIDENTS

3 INTRODUCTION 3-1

3.1 CHARACTERISTICS OF REPORTED INCIDENTS 3-4
  3.1.1 Where? 3-4
  3.1.2 When? 3-5
  3.1.3 Who? 3-9
  3.1.4 Situation? 3-11
  3.1.5 Summary 3-13

3.2 RISK OF COLLISION 3-13

3.3 COMPARISON WITH AIRCRAFT MOVEMENTS 3-17

3.4 FACTORS CONTRIBUTING TO INCIDENTS 3-20

3.5 SAFETY ISSUES 3-24
  3.5.1 Workload vs Error Rate 3-24
  3.5.2 Traffic Congestion 3-26

3.6 OBSERVATIONS 3-26

CHAPTER 4 EQUIPMENT

4 INTRODUCTION 4-1

4.1 AIRPORT CONTROL TOWERS 4-2
  4.1.1 GENERAL 4-2
  4.1.2 WORKSTATIONS 4-3
  4.1.3 VISIBILITY PROBLEM ON THE AIRPORT 4-4

4.2 THE AREA CONTROL CENTRE 4-4
  4.2.1 GENERAL 4-4
  4.2.2 CONSOLES 4-5
  4.2.3 INDICATOR MODULES 4-6

4.3 COMMUNICATIONS 4-7
  4.3.1 GENERAL 4-7
  4.3.2 DCPC ON THE NORTH ATLANTIC 4-7
  4.3.3 FREQUENCY AND TELEPHONE AVAILABILITY 4-10
  4.3.4 HEADSETS 4-11

TABLE OF CONTENTS

4.4 SURVEILLANCE SYSTEMS 4-12
    4.4.1 GENERAL 4-12
    4.4.2 RADAR QUALITY 4-13
    4.4.3 RADAR SCHEDULED SHUTDOWNS 4-15
    4.4.4 NORTH ATLANTIC SURVEILLANCE 4-15

4.5 AUTOMATED SYSTEMS 4-18
    4.5.1 GENERAL 4-18
    4.5.2 JOINT ENROUTE TERMINAL SYSTEM (JETS) 4-19
    4.5.3 NORTHERN AREA CONTROL SYSTEM (NACS) 4-20
    4.5.4 GANDER AUTOMATED AIR TRAFFIC SYSTEM (GAATS) . . 4-21
    4.5.5 SYSTEMS APPROACH 4-22

4.6 THE FUTURE 4-23

4.7 OBSERVATIONS 4-26

CHAPTER 5 STAFFING AND WORKLOAD

5 INTRODUCTION 5-1

5.1 FACTORS IN THE STAFFING SHORTAGE 5-1
    5.1.1 RESOURCE ALIGNMENT PROJECT (RAP) 5-1
    5.1.2 FIRST LINE SUPERVISOR 5-2
    5.1.3 A-BASE AND ATS STAFFING STRATEGY 5-3
    5.1.4 OTHER GOVERNMENT POLICY 5-4
    5.1.5 DELAYS TO RECOVERY: 5-5

5.2 CURRENT STAFFING LEVELS: 5-6
    5.2.1 ATTRACTING STAFF TO BUSY ACCs 5-9
    5.2.2 RECENT STAFFING INITIATIVES 5-9

5.3 SAFETY IMPLICATIONS 5-11

5.4 STAFFING PROGNOSIS: 5-13

5.5 CONTROLLER WORKLOAD 5-15
    5.5.1 GENERAL 5-15
    5.5.2 IFR WORKLOAD 5-15
    5.5.3 AIRPORT CONTROL WORKLOAD 5-16
    5.5.4 THE WORK DAY 5-16
    5.5.5 WORKLOAD TODAY 5-17

5.6 OPENING AND CLOSING OF SECTORS 5-18

TABLE OF CONTENTS

5.7 RELIEF AND REST PERIODS: 5-20

5.8 OVERTIME: 5-24
  5.8.1 STAFFING AND OVERTIME 5-24
  5.8.2 IMPACT OF CONTRACTUAL PROVISIONS 5-26
  5.8.3 OVERTIME EFFECTS 5-27

5.9 OBSERVATIONS 5-29

CHAPTER 6 TRAINING

6 INTRODUCTION 6-1

6.1 RECRUITMENT AND SELECTION 6-1

6.2 PRE-LICENSE TRAINING 6-2
  6.2.1 BASIC TRAINING 6-2
  6.2.2 QUALIFICATION TRAINING 6-3

6.3 AIR TRAFFIC CONTROL TRAINING FACILITIES 6-4
  6.3.1 GENERAL 6-4
  6.3.2 AIR TRAFFIC SERVICES TRAINING CENTRE 6-5
  6.3.3 SIMULATION 6-6
  6.3.4 REPORTING RELATIONSHIPS 6-8
  6.3.5 INSTRUCTIONAL STAFF 6-9

6.4 TRAINING OUTPUT VERSUS DEMAND 6-11

6.5 LENGTH OF COURSE 6-11

6.6 TRAINING ATTRITION 6-13

6.7 POST LICENSE TRAINING 6-16
  6.7.1 REFRESHER TRAINING 6-16
  6.7.2 ON-THE-JOB INSTRUCTOR TRAINING: 6-17
  6.7.3 UP-DATE TRAINING: 6-18
  6.7.4 SUPERVISORY TRAINING 6-18

6.8 OBSERVATIONS 6-18

TABLE OF CONTENTS

CHAPTER 7 SUPERVISION

7 INTRODUCTION 7-1

7.1 ROLE OF THE SUPERVISOR 7-1

7.2 PROBLEM AREAS 7-3
  7.2.1 OPERATIONAL OVERVIEW 7-5
  7.2.2 WORKLOAD DISTRIBUTION 7-8
  7.2.3 CONTROLLER DISCIPLINE AND DEPORTMENT 7-9

7.3 SUPERVISORY STAFFING 7-10

7.4 QUALITY CONTROL PROGRAMS 7-11

7.5 OBSERVATIONS 7-12

CHAPTER 8 OPERATING PROCEDURES

8.1 GENERAL 8-1
  8.1.1 Need For Standard Operating Procedures 8-1
  8.1.2 Procedures Development 8-2

8.2 COMMON PROBLEM AREAS 8-5
  8.2.1 Non-compliance 8-5
  8.2.2 Resistance To Change 8-7
  8.2.3 Competence Of Procedures Specialists 8-8
  8.2.4 Implementation Of New Procedures 8-8
  8.2.5 Transfer Of Control 8-10
  8.2.6 Sector Opening / Closing 8-12
  8.2.7 Coordination Procedures 8-13
  8.2.8 Wrong-way Altitude Assignments 8-14

8.3 SITE SPECIFIC PROBLEMS 8-16
  8.3.1 General 8-16
  8.3.2 Toronto 8-16
    8.3.2.1 SECTORIZATION 8-16
    8.3.2.2 TERMINAL PROCEDURES 8-17
    8.3.2.3 FLOW CONTROL 8-18
  8.3.3 Vancouver 8-19
    8.3.3.1 VFR/IFR MIX 8-19
    8.3.3.2 DEPARTURE PROCEDURES 8-22

TABLE OF CONTENTS

8.3.4 Montreal 8-23
  8.3.4.1 TERMINAL PROCEDURES 8-23
  8.3.4.2 NORTHERN PROCEDURES 8-23

8.3.5 Gander 8-24
  8.3.5.1 OCEAN PROCEDURES 8-24
  8.3.5.2 GANDER DOMESTIC AIRSPACE 8-24

8.4 OBSERVATIONS 8-25

CHAPTER 9 HUMAN PERFORMANCE FACTORS

9.1 GENERAL 9-1

9.2 WORKLOAD 9-3

9.3 VIGILANCE 9-5

9.4 DISTRACTION 9-6

9.5 BOREDOM 9-7

9.6 SHIFTWORK 9-8

9.7 OVERTIME 9-10

9.8 FATIGUE 9-14

9.9 STRESS 9-17

9.10 AEROMEDICAL CONSIDERATIONS 9-18

9.11 ATC OCCUPATIONAL HEALTH PROGRAM 9-20

9.12 PERSONAL MOTIVATION 9-21

9.13 VISUAL PERCEPTION 9-24

9.14 OBSERVATIONS 9-26

TABLE OF CONTENTS

CHAPTER 10 INFORMATION TRANSFER

10.1 GENERAL 10-1

10.2 THE COMMUNICATIONS PROCESS 10-4

10.3 COMMON SOURCES OF BREAKDOWN IN ORAL COMMUNICATIONS 10-5

10.4 COMMUNICATION PROBLEMS UNIQUE TO GANDER 10-17

10.5 OTHER COMMUNICATION PROBLEMS 10-20

10.6 OBSERVATIONS 10-22

CHAPTER 11 MANAGEMENT

11.1 GENERAL 11-1

11.2 NATIONAL PLANNING 11-1
  11.2.1 The Canadian Airspace Systems Plan (CASP) . . 11-2
  11.2.2 Canadian Airspace Review (CAR) 11-5

11.3 STAFF PLANNING 11-7

11.4 PLANNING IN ATC OPERATIONS 11-9

11.5 EMPLOYEE/MANAGEMENT RELATIONS 11-12
  11.5.1 Employee Confidence In Management 11-13
  11.5.2 Managerial Contact 11-14
  11.5.3 Competence of Controllers 11-15
  11.5.4 Operational Condition Report (OCR) Program . 11-16

11.6 SAFETY EDUCATION 11-17

11.7 QUALITY CONTROL 11-18

11.8 CANADIAN AIR TRAFFIC CONTROL ASSOCIATION 11-19

TABLE OF CONTENTS

11.9 INVESTIGATION OF ATS OCCURRENCES 11-21

11.10 OBSERVATIONS 11-25

CHAPTER 12 CONCLUSION

12.1 GENERAL 12-1

12.2 SAFETY ACTION REQUIRED 12-2
    12.2.1 EQUIPMENT 12-2
        12.2.1.1 Modernization 12-3
        12.2.1.2 Real-Time Surveillance on the North Atlantic 12-3
        12.2.1.3 DCPC over the North Atlantic 12-3
        12.2.1.4 Technology Enhancements 12-4
        12.1.1.5 Airborne Collision Avoidance Systems . 12-4
        12.2.1.6 Control Tower Layout 12-4
        12.2.1.7 Indicator Modules 12-5
        12.2.1.8 Frequency and Telephone Availability 12-5
        12.2.1.9 Headsets 12-5
    12.2.2 STAFFING AND WORKLOAD 12-6
        12.2.2.1 Staffing 12-6
        12.2.2.2 Overtime 12-6
    12.2.3 TRAINING 12-7
        12.2.3.1 Production 12-7
        12.2.3.2 Attrition 12-7
        12.2.3.3 Instructor Availability 12-7
        12.2.3.4 Instructor Training 12-7
        12.2.3.5 Simulation 12-7
        12.2.3.6 Refresher Training 12-9
    12.2.4 SUPERVISION 12-9
        12.2.4.1 Role 12-9
        12.2.4.2 Incentives to Supervise 12-9
        12.2.4.3 Training for Supervisors 12-9
    12.2.5 OPERATING PROCEDURES 12-10
        12.2.5.1 Introducing Change 12-10
        12.2.5.2. Transfer of Control 12-10
        12.2.5.3 VFR/IFR Mix 12-10
        12.2.5.4 Opening and Closing Sectors 12-11
    12.2.6 HUMAN PERFORMANCE FACTORS 12-11
        12.2.6.1 Vigilance 12-11
        12.2.6.2 Fatigue 12-11
        12.2.6.3 Aeromedical Consideration 12-12
        12.2.6.4 Visual Perception 12-12

TABLE OF CONTENTS

12.2.7 INFORMATION TRANSFER 12-12
    12.2.7.1 Awareness of Problems 12-12
    12.2.7.2 Callsigns 12-13
    12.2.7.3 Phraseology 12-13
    12.2.7.4 Coordination 12-13
    12.2.7.5 Gander Paper Handling 12-14

12.2.8 MANAGEMENT 12-14
    12.2.8.1 Staff Planning 12-14
    12.2.8.2 Operational Decision Making 12-15
    12.2.8.3 Employee/Management Relations 12-15
    12.2.8.4 Safety Promotion 12-15
    12.2.8.5 Quality Control 12-15
    12.2.8.6 Investigation of ATS Occurrences . . . 12-16

CHAPTER 1

1 INTRODUCTION

> "The willingness to recognize, report and examine conditions that require remedy is the foundation of flight safety".
>
> Earl L. Wiener

1.1 BACKGROUND

From time to time since its inception in October 1984, the Canadian Aviation Safety Board (CASB)[*] has had safety concerns with respect to the provision of air traffic control services (ATC) in Canada. Staff and Board Members monitoring Transport Canada's Civil Aviation Daily Occurrence Reporting System (CADORS) noted the frequency and potential severity of occurrences with a risk of collision - either on the ground or in the air. Following a review of the overall situation, the Board convened a public inquiry in May 1986 into the problem of ground conflicts. The CASB's report[1] on this Special Investigation was made public in August 1987 and included 28 Aviation Safety Recommendations to reduce the risks of collisions involving aircraft on or near the ground at Canadian civil airports.

Concurrent with the Special Investigation into the risks of collisions involving aircraft on or near the ground, the CASB staff pursued the issue of potential mid-air collisions between aircraft. During the CASB's first two years of operation, Transport Canada conducted approximately 300 internal investigations into those operating irregularities in ATC services which were not investigated by the CASB. Reports on these internal Transport Canada investigations, known as "Fact Finding Board" (FFB) reports are reviewed by CASB staff. Generally, the terms of reference for FFBs include accounting for the relationship between the circumstances of an occurrence and Air Traffic Services (ATS) policies, procedures, and guidelines. Frequently, systems deficiencies are identified and subsequently rectified in-house by Transport Canada. The routine review by CASB staff of cause factors assigned to individual FFB reports and the Transport Canada follow-up action thereto did not reveal any specific areas of serious safety concern. However, considering the likelihood of increased traffic growth and the possibly increased potential for losses in separation, it was decided that a more comprehensive analysis of the information contained in these reports was warranted.

---

[*] See Glossary for all abbreviations and acronyms.

In March 1987, a consultant was hired to examine the data held by the CASB on 294 ATS operating irregularities. The objective of the consultant's study was to determine if there were any significant trends in FFB reports on ATS operating irregularities which might indicate fundamental safety deficiencies in ATC operations. To protect the confidentiality of the FFB reports, the consultant was only provided with summaries of the essential information extracted from the FFB reports.

The principal objective of this study was met. The consultant found that "fact finding boards were generally of excellent quality and appeared to be both objective and thorough." The study determined that there were no alarming trends or safety deficiencies requiring urgent CASB safety action. However, the study did underline the prevalence of human factors in the circumstances leading up to ATS operating irregularities. While most incidents involved more than one cause factor, "judgement" was cited as contributory in 182 occurrences, "attention" in 170 occurrences, and "communications" in 99 occurrences.

While the report supported the current FFB process with respect to the maintenance of air safety, limitations in the source data restricted the utility of many of the conclusions made by the consultant. For example, the consultant was not required to correlate occurrence data with air traffic volume. A copy of this report[2] was sent to Transport Canada for their information.

In June 1987, Transport Canada contracted Dr. Paul Stager, a consultant in human factors, to carry out an analysis of some 320 ATS operating irregularities to identify the factors which precipitate such events. Dr. Stager made several notable findings.[3] For example:

- Approximately 75 per cent of the incidents involved two IFR aircraft and 60 per cent of the incidents involved aircraft within the same weight class. Just over 50 per cent of the incidents occurred within terminal control and approximately 30 per cent were wholly under en route control.

- The most frequently recurring weight, flight rule, and jurisdiction combination comprised two heavy, en route aircraft operating under instrument flight rules (IFR). Due to the very nature of transoceanic traffic, half of the incidents matching this combination occurred in the Gander Oceanic Flight Information Region (FIR), and nearly all were low-risk occurrences involving a technical loss of separation.

- Operating irregularities are most likely to occur under the conditions of moderate or low workload, normal complexity, and intermediate pace levels.

- Attention, judgement, and communications were the primary categories of error most frequently cited in the FFB reports. Within these primary categories non-recognition of conflict, inattention, deviation from the ATS Manual of Operations (MANOPS), coordination, and poor judgement were the most frequently cited errors.

- Approximately 68 per cent of all incidents occurred below 9,000 feet and 62 per cent occurred when visibility was greater than 10 miles.

Subsequent to the in-house CASB study undertaken at reference 2, the CASB staff and the Board remained concerned over the frequency of ATS operating irregularities. In addition, media reports, shaped by the widely publicized concerns over safety in ATC in the U.S., were questioning the adequacy of the Canadian ATC system. During this time, the CASB improved in its investigation of ATS occurrences, the identification of safety deficiencies, and the issuance of related safety action. The Investigations Branch had hired a qualified air traffic controller, and a draft ATS investigation manual was issued to the regional offices. In addition, a specialized training program was undertaken with regional investigators to enhance the investigation of ATS occurrences. Nonetheless, in view of the potential gravity of a midair collision involving a large passenger-carrying aircraft, a multi-disciplinary project was undertaken for the investigation and analysis of ATS occurrences, as a high priority for Fiscal Year (FY) 1988-89. The focus of this project was on near midair collision situations involving at least one aircraft operating under IFR and one aircraft of 5 700 kilograms maximum take-off weight (MTOW). Work on this project continued into the late fall of 1988.

Subsequent to a series of losses of separation between aircraft at Lester B. Pearson International Airport (LBPIA) in late 1988, the Board began to consider the possible need for a public inquiry into the circumstances at LBPIA which might lead to a midair collision. In December 1988, the Board considered trends in ATS occurrence data in Canada and weighed the pros and cons of a possible public inquiry. The Board decided to meet with key representatives of the Canadian aviation community in early 1989 to discuss the possible need for such an inquiry into the safety aspects contributing to operating irregularities in ATS in Canada. Representatives of the Canadian Air Traffic Controllers Association (CATCA), the Canadian Airline Pilots Association (CALPA), the Air Transport Association of Canada (ATAC), and

Transport Canada met with the Board on separate occasions to give their evaluation of safety concerns associated with the provision of ATC services in Canada and to review current activities towards alleviating any such deficiencies. As a result of this dialogue, the Board recognized that, in addition to the overriding safety considerations, such an inquiry would inevitably address issues of management, airport capacity, and efficiency of the ATC system. Since such an inquiry had a good probability of straying beyond the strict safety mandate of the CASB, the Board called upon the Minister of Transport to cause an independent public inquiry to address all aspects of the Canadian ATC system. Furthermore, the Board decided on 21 February 1989 to conduct a Special Investigation of the safety aspects of the current ATC situation in Canada. This Special Investigation was to include a comprehensive review of aviation occurrences involving losses in separation between aircraft and all the factors underlying those occurrences, culminating in a public report with appropriate recommendations.

1.2 AIM

The objectives of this Special Investigation were as follows:

a. To identify safety deficiencies in the ATS system contributing to occurrences involving loss of safe separation between aircraft in flight under the control of a Canadian ATC Unit; and

b. To make recommendations to alleviate these safety deficiencies.

1.3 SCOPE

To stay within the confines of the CASB's mandate of advancing aviation safety, to capitalize on work already completed with respect to the adequacy of ATC services in Canada, and to keep the workload manageable and provide meaningful results in a timely manner, the scope of this Special Investigation was confined as follows:

a. Only factors deriving from the ATS system itself were examined. These included human factors pertaining to controllers and their workload, ATC equipment and procedures, and the ATC work environment. Factors deriving from airport capacity limitations, aircraft equipment, or flight-crew capabilities were only included to the extent that they affect controllers' or flight crews' abilities to safely fulfil their responsibilities with respect to maintaining safe separation of aircraft in flight. In other words, the focus was on ATS safety-related issues, rather than on issues related to the efficiency in the provision of Canadian ATC services.

b. Investigation and analysis was focused primarily on those aviation occurrences that:

   - involved at least one IFR aircraft weighing more than 5 700 kilograms; and
   - occurred in the Toronto or Vancouver Terminal Control Areas; (en route traffic within these Terminal Control Areas was considered only as it affected arrivals and departures); or
   - occurred en route in high-level airspace under Canadian control.

These occurrences were considered to provide data representative of the aviation occurrences involving the Canadian ATC system.

1.4 CONDUCT OF SPECIAL INVESTIGATION

A file review was conducted of more than 200 FFB reports and CASB investigations dating back to 1985, with principal emphasis placed upon those occurrences involving the Toronto or Vancouver ACCs or which occurred in the high-level structure. "What" happened and "why" it happened were coded for each of these occurrences to facilitate subsequent analysis. For the most part, the contributing cause factors could be assigned to one of 12 broad categories: equipment, coordination/communications, sector configuration, procedures, controller training and knowledge, staffing, workload, forgetfulness/inattention/ distraction, fatigue, planning, judgement, and/or pilot error.* (Chapter 3 contains a complete resume of the data analysis phase).

Based upon the preliminary findings of the file review phase, a field survey was conducted to obtain first-hand information concerning the foregoing 12 principal areas of concern from the personnel providing air traffic services. More than 80 interviews were conducted at the Area Control Centres (ACCs) of Vancouver, Toronto, Montreal, and Gander. Representative controllers from all subunits and specialties[*] were interviewed along with representative supervisors, shift managers, the Managers of ACC Operations (MACCOs), the General Managers and other personnel, such as the Managers for ATC Operational Requirements and the Managers for Training and Human Resources.

---

* "Pilot error" in this report is used simply to reflect any type of shortcoming in expected human performance by the flight crew. It is not meant to assign blame or liability. Nor does it reflect the operating context in which the shortcoming occurred.

As part of the field survey phase, interviews were held with staff of the ATC Occupational Health Programs at both Vancouver and Toronto to assess the impact of current workload levels on individuals. Discussions were held with representatives of the Canadian Air Traffic Control Association (CATCA), the Canadian Airline Pilots Association (CALPA), the Air Transport Association of Canada (ATAC) and the Canadian Business Aircraft Association (CBAA) to learn of these associations' perspectives on the current levels of safety in the provision of ATC services in Canada. Also, discussions were held with the Chief of the ATS Training Centre and with the Chief of Training and Human Resources Development to assess the adequacy of the current ATC training system to provide the requisite numbers of qualified controllers to maintain safe levels of ATS operations.

To assist the CASB staff, the professional services of a retired air traffic controller/Unit Chief/Regional Manager were retained for the file review, the field survey, and the report writing phases. In addition, a second former air traffic controller participated with this consultant during the report writing phase.

This report was drafted drawing upon the analysis of the data obtained through the file review, as well as the recurrent themes exposed through the field survey interviews and meetings. Where applicable, references were also made to associated research and literature. The report therefore draws upon the factual basis of the Canadian occurrence record as well as the collective views of the many people involved in this Special Investigation.

The initial draft of this technical staff report was reviewed during a two-day working session with several experts from the ATS Branch of Transport Canada to ensure a balanced perspective in the report. Subsequently, technical representatives of CATCA, CALPA, ATAC, the Canadian Owners and Pilots Association (COPA), and the Canadian Business Aircraft Association (CBAA) met with CASB and Transport Canada staff members, again to ensure fairness and accuracy in the report. No attempt was made during these meetings to find agreement among these representatives as to the remedial measures warranted - that being the domain of the Board itself.

---

[*] Specialties and subunits refer to the operational divisions within an ACC; the two terms are considered to be synonymous in this Report.

Each chapter of this staff report includes a set of observations which summarize the principal points of that chapter. Chapter 12, Conclusions, draws upon the recurring themes of these observations and makes some conclusions as to the types of safety action deemed necessary.

List of References

1. CASB Report #87-SP001 "Report on a Special Investigation Into the Risk of Collisions Involving Aircraft On or Near the Ground at Canadian Civil Airports" adopted 23 June 1987.

2. "Trend Analysis of Air Traffic Services Operating Irregularities 1984-1986" prepared for the CASB by EER Technologies Incorporated April 1987.

3. TP9342E "Factors Associated With Air Traffic Control Operating Irregularities, an Analysis of Fact Finding Board Reports" prepared for the Air Traffic Services Evaluation Division by Paul Stager and Donald Hameluck, February 1988.

CHAPTER 2

THE ATS SYSTEM

2 INTRODUCTION

For those readers not already familiar with the Canadian ATS system, this chapter provides a brief description of the structure of the airspace in Canada, the organization of the ATS system for the provision of ATC services in Canada, and the changing air traffic volume and complexity in Canada. This chapter is not intended to analyse specific safety-related issues; these will be addressed in subsequent chapters.

2.1 AIRSPACE STRUCTURE

Canadian airspace is divided into a number of categories which, in turn, are subdivided into a number of areas and zones. Rules for the conduct of flight within these various areas and zones are simplified through the classification of all Canadian airspace.

2.1.1 Canadian Domestic Airspace

Canadian Domestic Airspace includes all airspace over the Canadian land mass, the Canadian Arctic, the Canadian Archipelago, and those areas of the high seas within the airspace boundaries. Since magnetic compass indications may be erratic in the vicinity of the magnetic North Pole, true track is required to determine cruising altitudes for direction of flight in the north in lieu of magnetic track. Hence Canadian Domestic Airspace is divided into Northern Domestic Airspace (where true track is used) and Southern Domestic Airspace (where magnetic track is used).

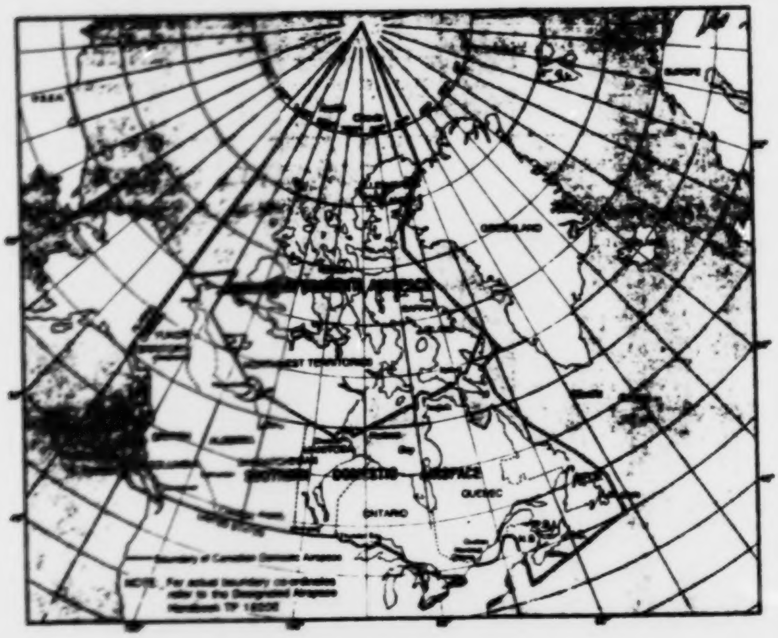


Figure 2-1
Canadian Domestic Airspace

Canadian Domestic Airspace is further divided vertically into the low-level airspace, which consists of all the airspace below 18,000 feet above sea level (asl) and the high-level airspace which consists of all airspace from 18,000 feet asl and above. Cruising altitudes and flight levels are prescribed dependent upon the magnetic (or true) track of the aircraft, whether the aircraft is on a VFR or IFR flight plan, and whether or not the aircraft is in high- or low-level airspace.

2.1.2 Minimum Navigation Performance Specification Airspace

The International Civil Aviation Organization (ICAO) has designated the airspace between flight level 275 and flight level 400, between latitudes 27 degrees North and the North Pole over the Atlantic Ocean as an area in which all aircraft operating within the defined airspace boundaries must be equipped and crewed so as to meet established Minimum Navigation Performance Specifications. This airspace is known as the North Atlantic Minimum Navigation Performance Specifications Airspace (NAT MNPSA).

As a continuation and to ensure that the flow of traffic transiting to and from the North Atlantic Airspace to Canadian

Airspace is accommodated efficiently, Canada has also designated performance specifications for the airspace that interacts with the North Atlantic Track System and the North American routes and airways system; this airspace is known as the Canadian Minimum Navigation Performance Specification Airspace (CMNPSA).

Compliance with these specifications is required to ensure both the safe separation of aircraft and to enable operators to derive maximum benefit from their navigation equipment for minimum time (and therefore fuel efficiency) en route. Traffic operating within these areas will be cleared on specific tracks based on MNPS.

On a daily basis, two organized systems of tracks for the eastbound and westbound North Atlantic traffic flow are established. The eastbound flow is typically on four to five tracks and operates during late evening and early morning, while the westbound flow is on four to six tracks and operates during the afternoon. The duration of each flow is between four and six hours.

While in North American Airspace, the North Atlantic traffic is routed via the North American Route System. This routing system has been developed by Transport Canada and the Federal Aviation Administration (FAA) of the U.S.A., in cooperation with the international aviation community, to better manage traffic flow safely and efficiently to and from the Organized Track Structure over the North Atlantic.

2.1.3 Flight Information Regions

A Flight Information Region (FIR) is an airspace of defined dimensions extending upwards from the surface of the earth, within which flight information services and alerting services are provided. The Canadian Domestic Airspace is divided into seven FIRs; i.e., the Vancouver, Edmonton, Winnipeg, Toronto, Montreal, Moncton, and Gander Domestic FIRs. In addition, ICAO has allocated to Canada the responsibility for providing flight information and alerting services over that portion of the North Atlantic within the Gander Oceanic FIR.

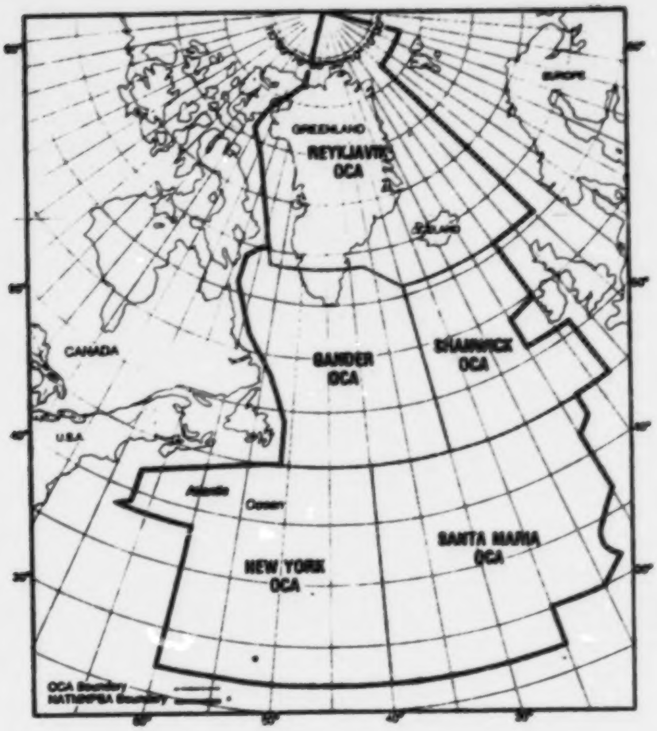

EUROPE
GREENLAND
REYKJAVIK OCA
ICELAND
CANADA
GANDER OCA
SHANWICK OCA
U.S.A.
Atlantic Ocean
NEW YORK OCA
SANTA MARIA OCA
OCA Boundary
NAT/MNPSA Boundary

Figure 2-2
Oceanic Control Areas

2.1.4 Controlled Airspace

ATC services are not provided throughout all Canadian Domestic Airspace. Hence, controlled airspace is the airspace within which ATC services are provided and within which some or all aircraft may be subject to ATC. Examples of controlled airspace include high- and low-level airways, terminal control areas, and control zones. In controlled airspace, controllers are required to protect an envelope of airspace around each IFR aircraft to provide separation from other air traffic based upon standard separation criteria.

2.1.5 High-Level Controlled Airspace

Controlled airspace within the high-level airspace is divided into three separate areas. The Southern Control Area (18,000 feet asl and above), the Northern Control Area (Flight Level (FL) 230 and above) and the Arctic Control Area (FL280 and above).

The volume and concentration of international air traffic transiting the Northern and Arctic Control Areas on random tracks can create en-route penalties to users by preventing maximum utilization of the airspace. To ensure the flow of traffic is accommodated efficiently, a track system has been established which interacts with the established airways system. In addition, aircraft flying between FL330 and 390 in the Northern or Arctic Control areas must be equipped and crewed to operate in accordance with Canadian Minimum Navigation Performance Specifications.

2.1.6 Low-Level Airspace

Controlled low-level airspace extends upwards from 2,200 feet above ground level (agl) up to, but not including 18,000 feet asl, within specified boundaries.

Low-level airways are established between fixed ground-based navigational aids (e.g., VORs or NDBs) and have a minimum width established on each side of the centre line to ensure adequate protected airspace for safe navigation under IFR. Control zones have been designated around certain aerodromes to keep IFR aircraft within controlled airspace during approaches and to facilitate the segregation of VFR and IFR traffic. The dimensions of control zones depend in part upon the availability of local radar control services but are generally between three and seven nautical miles radius from the aerodrome. In addition, control area extensions and transition areas are sometimes established to provide additional controlled airspace of defined dimensions to facilitate IFR control outside low-level airways or control zones.

2.1.7 Use Of Controlled Airspace By VFR Aircraft

Due to the speeds of modern aircraft, the difficulty in visually observing other aircraft at high altitudes, and the density of air traffic at certain locations and altitudes, the "see and be seen" principle for the conduct of VFR flights cannot always ensure positive separation; i.e., the pilot's visual acquisition of traffic under such conditions is not reliable. Accordingly, in certain airspace and at certain altitudes, VFR flight is either prohibited or subject to specific restrictions prior to entry and during flight. In this regard, Canadian Domestic Airspace is further subdivided into six classes of airspace, each identified by a specific letter. In Class A airspace, VFR flight is prohibited. In Classes B, C, and D airspace, VFR flights are permitted under specific conditions. In Class E airspace, ATC has neither the authority nor the responsibility for exercising control over air traffic; hence, VFR flights are not restricted in Class E airspace. Class F airspace is airspace of defined dimensions within which activities must be confined because of their nature and/or within which special limitations may be imposed upon aircraft operations, including VFR operations. Class F airspace may be controlled or uncontrolled (e.g., danger areas, rocket ranges, military flying areas).

2.2 ORGANIZATION OF CANADIAN AIR TRAFFIC SERVICES

2.2.1 General

The Canadian Air Traffic Services organization is responsible for providing ATC and advisory services in the Canadian Domestic Airspace and in the international airspace over the North Atlantic as delegated by ICAO. This represents an area of some 15 million square kilometres. Air traffic services are provided for the safe, orderly, and expeditious flow of air traffic in accordance with Annex II to the ICAO convention.

In Canada these services include the following:

a) ATC Services which include those services provided by ACCs to IFR and controlled VFR aircraft operating within specified control areas; terminal control service within established terminal control areas; airport control service on or around controlled airports; and terminal (VFR) radar service provided by ATC units to VFR aircraft operating within designated Class C airspace, formerly known as Terminal Radar Service Areas (TRSAs).

b) Flight Information Service including information on adverse weather conditions, radar-observed traffic information, radar assistance on request from aircraft operating within radar coverage and desiring position information or navigational guidance, and radio direction-finding assistance to aircraft operating within the range of stations so equipped. Those flight service stations (FSSs) located at airports without operating control towers also assist ATC units in providing flight information services.

c) Alerting Services primarily to notify appropriate agencies when an aircraft is in need of search and rescue aid.

d) Altitude Reservation Service to provide reserved airspace for specified air operations in controlled airspace.

e) Aircraft Movement Information Service for the collection, processing, and dissemination of aircraft movement information for use by air defence units;

f) Customs Notifications Service to notify customs agents of non-scheduled transborder flights at airports where custom services are available.

2.2.2 Air Traffic Services Units

The ATS Branch of Transport Canada provides air traffic services through seven area control centres, eight terminal control units (TCUs), 60 control towers and 108 FSSs - for a total of 183 ATS units.

The Area Control Centre: The ACC is the nerve centre of the ATS system. The seven ACCs in Canada are located at Vancouver, Edmonton, Winnipeg, Toronto, Montreal, Moncton, and Gander. Each ACC has responsibilities for all aircraft movements within its designated FIR. However, its prime function is to control and monitor all IFR and VFR aircraft while en route between airports.

To achieve this in a safe and expeditious way, the airspace within a FIR is divided into defined blocks of airspace of geographical and vertical dimensions, known as sectors. The number of sectors within an ACC is based mainly on the amount of traffic, the air route structure, the complexity of the flow, and hence, the workload. There are over 100 sectors in the seven ACCs in Canada with some 250 control positions. As a rule, sectors where aircraft are descending, climbing, or transiting to or from a major airport are of smaller dimensions and of greater complexity than high-level en route or oceanic sectors.

For example, the Montreal ACC is sub-divided into four geographic areas of specialty (i.e., four subunits) as follows:

a) North subunit. Because of the general lack of radar coverage in the north, controllers of this subunit must be proficient in the application of non-radar separation standards, which have been developed over the years using complex mathematical risk probability models.

b) South subunit. At Montreal, this subunit uses a completely different form of control, based on radar separation criteria and procedures. The majority of the traffic is observed on radar and, unlike the en route flow within the North subunit, most aircraft in the South subunit are descending to or climbing from the Montreal airports.

c) East subunit. This subunit has a block of airspace within which radar is used to separate aircraft, and a block of airspace within which there is a requirement for non-radar control to and from the numerous airports under its jurisdiction.

d) Terminal Control. This subunit controls aircraft by providing radar vectors to the final approach courses for aircraft landing at Montreal's airports and to the en route airway structure for aircraft departing from Montreal. One Terminal Control specialty also provides advisory services to VFR flights transiting their area.

The staff required to support the operations of an ACC is between 200 and 350 consisting of air traffic controllers, operational support staff, automation systems analysts, radar and communication technicians, ATC specialists, training staff, and administrative support and management personnel. ACCs operate 24 hours a day and 365 days a year.

"Stand-Alone" Terminal Control Units (TCUs): In addition to five terminal control subunits collocated in ACCs, there are eight "stand-alone" TCUs (located at Halifax, Quebec, North Bay, Ottawa, Thunder Bay, Regina, Saskatoon and Calgary).

The Radar Modernization Project (RAMP) will see all the TCUs except those at Ottawa and Calgary integrated into ACCs. At present, "stand-alone" TCUs employ an older generation of radar display. Primarily, these units provide ATC services to arriving, departing, and overflying aircraft within their terminal control areas. The staff complement for a TCU is between 20 and 50 persons consisting of controllers, supervisors, operational specialists, and the administrative and management staff.

Airport Control Towers: Control towers are sited on 60 airports in such a fashion, ideally so as to provide a clear line of sight to all areas of the airport on which aircraft manoeuvre, and a clear view of air traffic in the vicinity of the airport. The airport controller clears and directs aircraft for take-offs, approaches, and landings in a prescribed manner designed to avoid confliction. Service is provided to all aircraft within a specified radius known as a control zone.

With the exception of the apron (i.e., aircraft parking areas), all movement by aircraft and vehicles on the operational area of the aerodrome is controlled by the ground controller. In addition, at busy airports, IFR aircraft about to depart generally receive their IFR clearance from a clearance delivery controller in the control tower.

When controlling IFR aircraft, control towers are in principle an extension of the IFR TCUs. Inter-unit agreements between towers and TCUs allow the air traffic to flow to and from these busy airports with the least delays by having well-established procedures where transfer of control from one unit to the other is effected. The total controller complement for a control tower varies from as few as 8 to 10 at smaller towers to between 25 and 40 at major towers, and the hours of operation vary in accordance with local requirements.

Flight Service Stations (FSS): Transport Canada operates 108 FSSs across Canada; most are located along established air routes and at both small and large airports. An FSS is established to provide pilots, aircraft operators, and others associated with aviation with information required for safe and efficient aircraft operations.

Where no direct controller pilot communications exist, the FSS will relay ATC clearances, instructions, and messages between an ACC and aircraft. For example, the Gander International FSS (IFSS) is equipped with a long-range high frequency (HF) network; it receives, relays, and transmits about 3,000 ATC messages a day between aircraft operating over the North Atlantic and the Gander Oceanic ACC. The accuracy and timeliness of these messages are crucial elements in maintaining a safe operation over the North Atlantic.

The number of staff at an FSS depends largely on the hours of operation and the services provided by the station. Normally there are between 5 and 15 specialists assigned to most stations; as many as 60 specialists are assigned to the Gander IFSS in support of the transoceanic traffic.

2.3 ATS ORGANIZATION WITHIN TRANSPORT CANADA

Transport Canada's organization for the provision of Air Traffic Services is depicted in Figure 2-3.

figure 3

TAKE FROM MASTER

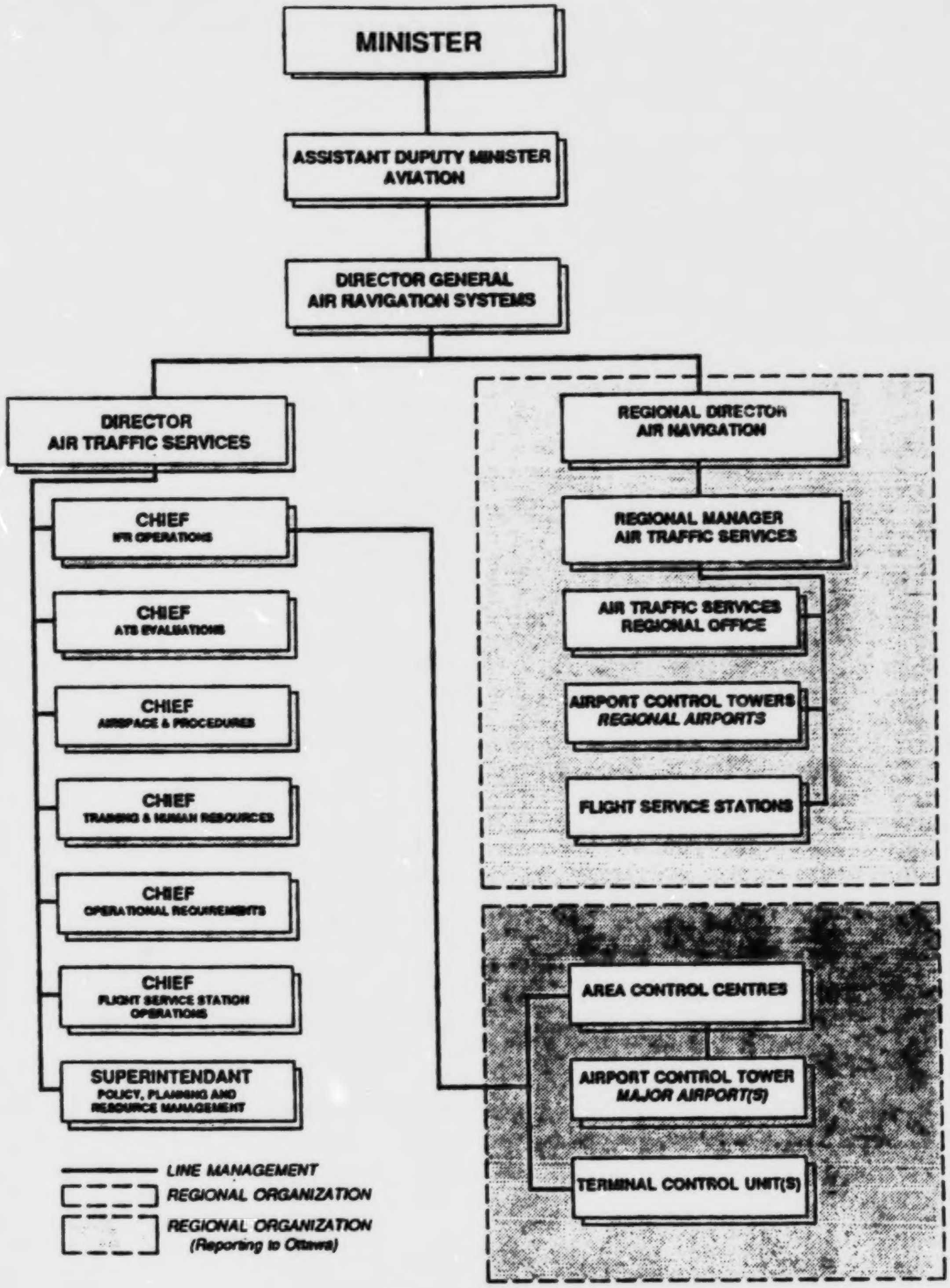

MINISTER
ASSISTANT DUPUTY MINISTER AVIATION
DIRECTOR GENERAL AIR NAVIGATION SYSTEMS
DIRECTOR AIR TRAFFIC SERVICES
CHIEF IFR OPERATIONS
CHIEF ATS EVALUATIONS
CHIEF AIRSPACE & PROCEDURES
CHIEF TRAINING & HUMAN RESOURCES
CHIEF OPERATIONAL REQUIREMENTS
CHIEF FLIGHT SERVICE STATION OPERATIONS
SUPERINTENDANT POLICY, PLANNING AND RESOURCE MANAGEMENT
REGIONAL DIRECTOR AIR NAVIGATION
REGIONAL MANAGER AIR TRAFFIC SERVICES
AIR TRAFFIC SERVICES REGIONAL OFFICE
AIRPORT CONTROL TOWERS REGIONAL AIRPORTS
FLIGHT SERVICE STATIONS
AREA CONTROL CENTRES
AIRPORT CONTROL TOWER MAJOR AIRPORT(S)
TERMINAL CONTROL UNIT(S)
LINE MANAGEMENT
REGIONAL ORGANIZATION
REGIONAL ORGANIZATION (Reporting to Ottawa)

Figure 2-3

The ATS Branch is one of four branches within the Air Navigation Systems Directorate. It is responsible for the operation of the ATS units described above. The IFR units (ACCs and TCUs), 14 major control towers, and the Gander IFSS report directly the IFR Operations Division in Transport Canada Headquarters in Ottawa. The other units report to a regional manager for ATS at the six regional offices.

In addition, Transport Canada operates an Altitude Reservation Unit and the Research and Experimentation Centre for Air Traffic Services, both located in the National Capital Region.

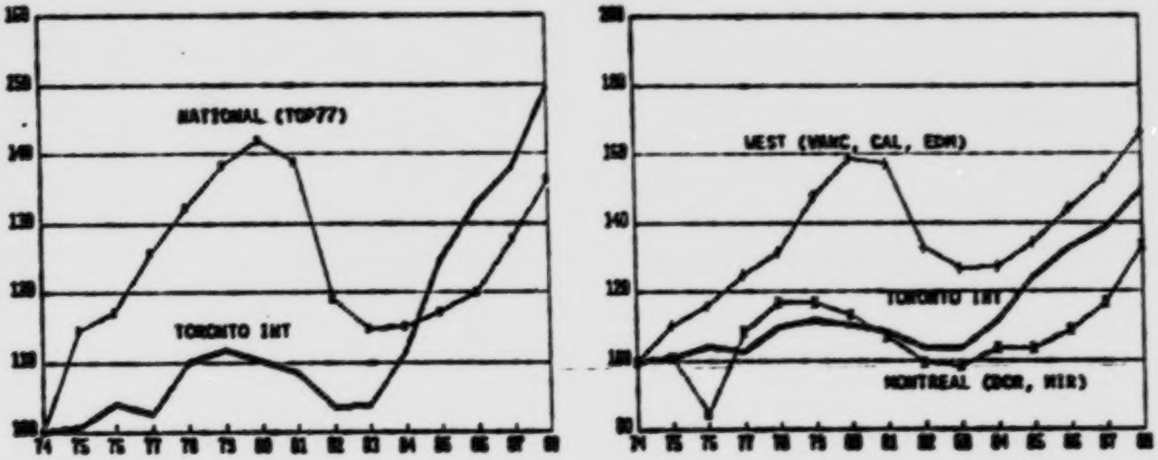
To fulfil its task, ATS was allocated 3,326 Person Years (PYs), and, as of 01 December 1988, 3,184 persons (including 1,831 controllers) were actually employed within ATS.

2.4 ACTIVITY RATES

Canadian aviation activity statistics have been quite volatile over the past decade. The economic recession of the early 1980s brought with it unprecedented declines in the numbers of aircraft movements at tower-controlled airports. With the economic recovery, traffic again began to increase in 1983, and the added impact of "economic regulatory reform" has resulted in dramatic increases in the traffic during the past five years. The effect of the latter factor has been particularly evident at the major airports such as Toronto which serve as the hubs in the "hub and spoke" network which now exists with the two major carriers and their affiliates.

The erratic growth pattern of the past decade is shown graphically in Figure 2-4. It is noteworthy that the total number of itinerant aircraft movements in 1988 at airports with control towers is still below the peak level attained in 1980. However, this does not apply to the six major airports depicted in Figure 2-4 - and particularly not at Toronto. Furthermore, in the context of controller workload and staffing (see Chapter 5), it must be noted that "itinerant movements" is only one rough indicator of controller workload. For IFR controllers, a much more relevant indicator is the number of flight plans handled by the ACCs.

Figure 2-4
Total Itinerant Aircraft Movements
(Index Year, 1974=100)



a) Toronto Intl. and national total

b) Six major airports

Source: An Evaluation of the Accuracy of Aviation Activity Forecasts for Toronto.
Transport Canada, Policy and Coordination, Feb. 1989.

Figure 2-5 reflects the increase in IFR flight plans handled by the seven Canadian ACCs between 1978 and 1988.

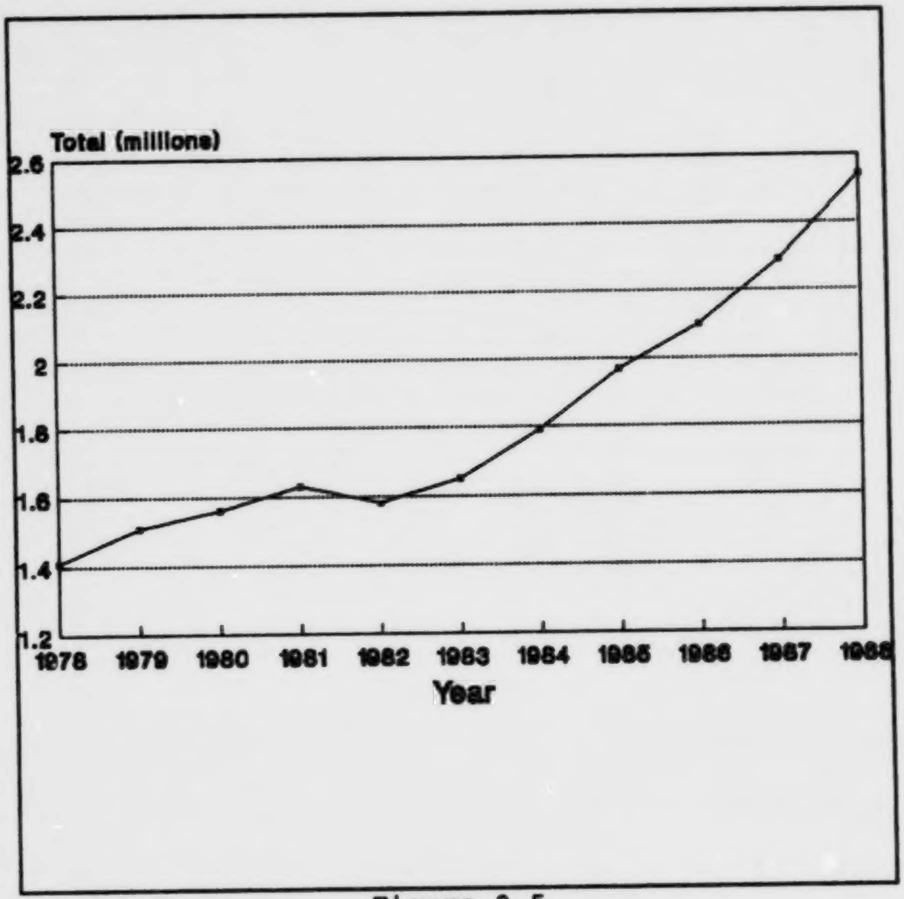


Figure 2-5
National ACC Unit IFR Flight Plans
(Annual Totals)

Source: Air Statistics and Forecasts
Policy and Coordination, Transport Canada

In contrast with Figure 2-4, this graph shows an increasing trend between 1978 and 1983 - with an average annual growth rate over the five year period of 3.2 per cent per annum. Again, there is a sharp upturn after 1983, and the average annual growth rate for the latter five years is 8.9 per cent. The following increases have been recorded by the individual ACCs between 1983 and 1988:

Toronto	ACC	70.4%
Vancouver	ACC	64.2%
Montreal	ACC	62.8%
Winnipeg	ACC	57.3%
Gander	ACC	54.9%
Moncton	ACC	38.5%
Edmonton	ACC	20.2%

The Director of ATS in Transport Canada has stated the view that, although these overall traffic increases are the primary reason for current staff shortages, a secondary effect of the "hubbing" concept introduced by the airlines (with its associated increase in regional carrier activity) has contributed significantly to the problem. Since the airlines are governed by market forces, traffic is not evenly distributed throughout the day, and there are peak demand periods that can not be accommodated by the current infrastructure. For example, at several locations, airlines schedule competing flights between 0700 and 0900 hours and between 1500 and 2000 hours. During these periods, demand exceeds the capacity of some airports, (e.g., Toronto and Vancouver), and therefore flow management and ground delay programs have been necessitated.

Since 12 December 1988, a cap of 70 flights per hour has been in effect at Toronto's Lester B. Pearson International Airport; 66 slots are allocated to flights proceeding to Terminals 1 and 2, and four slots are allocated to general aviation. The major objective in imposing this cap was to restore order to flight schedules while permitting ATS to manage the flow of aircraft and to minimize flight delays.

The current traffic volumes at Canada's largest airports are quite significant. Indeed, while these volumes are significantly below many U.S. airports, they are quite similar to the volumes at Europe's busiest airports as depicted in Table 2-1.

TABLE 2-1 TOTAL AIRCRAFT MOVEMENTS - 1988
(THOUSANDS)

CANADA		EUROPE	
Toronto (LBPIA)	347.7	London (Heathrow)	351.6
Vancouver	325.2	Frankfurt	281.5
Montreal (Dorval)	203.1	Amsterdam (Schiphol)	233.1
		Paris (Charles de Gaulle)	184.8

Source: Transport Canada Aircraft Movement Statistics and ICAO.

It should be noted that the corollary of high traffic growth at the largest Canadian airports is low growth, or even declines, at many small airports - given the fact that the national total is still below the 1980 peak (see Fig 2-4(a)). Statistics supplied by Transport Canada's Air Statistics and Forecasts Branch show that total itinerant aircraft movements at the 60 airports with ATC towers were 5 per cent lower in 1988 than in 1980. However, the "top 10" airports total increased by 7.5 per cent while the other towered airports were collectively 9 per cent below the 1980 level.

2.5 SUMMARY

In summary, Canadian airspace is logically divided into high-level and low-level airspace with further subdivision as necessary in order to meet the unique requirements of the airspace users and to facilitate the necessary degree of ATS. The equipment requirements, separation criteria, and operating procedures in these various segments of airspace differ in accordance with operational requirements.

To maintain a safe, orderly, and expeditious flow of air traffic, varying levels of ATC services and information services are provided throughout Canadian airspace. Seven ACCs, eight TCUs, 60 control towers, and 108 FSSs facilitate the provision of these services. Transport Canada employs more than 3,000 personnel, including more than 1,800 air traffic controllers, to operate these units.

Rapidly increasing activity rates throughout Canada are placing a significant burden on existing facilities and staff in maintaining the safe, orderly, and expeditious flow of traffic required.

CHAPTER 3

ANALYSIS OF CANADIAN INCIDENTS

3 INTRODUCTION

This chapter presents an analysis of data concerning loss of separation incidents in airspace for which Canada provides air ATC services. The analysis aims to provide an overview of the key characteristics of reported incidents and the factors contributing to those incidents, to the extent the factors are known. Finally, two of the principal safety issues which arose during this investigation are addressed. As far as possible, quantitative data which bear on these issues are presented.

The analysis is based on a database prepared especially for this Special Investigation. Data were extracted from information reported to the CASB by Transport Canada and others (airlines, pilots etc.), supplemented by information gleaned from Transport Canada FFB reports and CASB occurrence investigation reports. The scope of the database was defined as all reported incidents meeting the following criteria:

- The occurrence took place between 01 January 1985 and 31 December 1988. The year 1985 was used as the start date for these data because this was the first full year in which mandatory incident reporting to the CASB was in force; and

- There was a loss of separation between two or more aircraft. In this context, "separation" primarily refers to the requirements of Transport Canada's operating procedures for specific time or space separation between aircraft. However, for reports involving VFR aircraft or incidents reported by pilots, separation requirements are less clearly defined. In such cases, a judgement has been made that a safe separation was not maintained; and

- The incident involved at least one aircraft with a maximum take-off weight (MTOW) of over 5 700 kilograms. This restriction was applied because almost all transport-category aircraft fall in this weight range. In addition, the mandatory incident reporting to the CASB is restricted to occurrences involving aircraft in this weight range. This restriction should be borne in mind when considering the statistics presented, especially in relation to the relatively low numbers of incidents involving aircraft on VFR flight plans.

Based on this definition, data on a total of 710 incidents are included in the database; (only 513 of these, however, were recorded in the Canadian Accident/Incident Data System (CAIDS) maintained by CASB as discussed in Annex A to this chapter). Table 3-1 presents a breakdown of the sources of data for these 710 incidents, and also the numbers of incidents where data are based on a CASB investigation, a Transport Canada Fact Finding Board or where no data beyond that contained in the initial notification report of the incident to CASB are available.

TABLE 3-1
SOURCE OF DATA

CASB INVESTIGATION	CASB INITIAL NOTIFICATION (NO INVESTIGATION)	TC FACT-FINDING BOARD	OTHER	TOTAL
75	251	362	22	710

OTHER: Gross Navigational Error Reports
Air Traffic Services Infractions
Air Miss Reports from Airlines
Military and Foreign Agency Investigations

During the analysis, various subsets of these data were extracted for a number of reasons. In particular, the Special Investigation focused on three subgroups: incidents at Toronto, at Vancouver, and in high-level airspace. Incidents at Toronto and Vancouver were defined as all incidents included in the database which occurred within one-half of a degree of latitude and longitude of the published location of the airport. (This definition corresponds roughly to the Terminal Control Areas.) High-level incidents include all occurrences with one aircraft at a reported altitude over 18,000 feet (or FL180) not included in the Toronto or Vancouver groups.

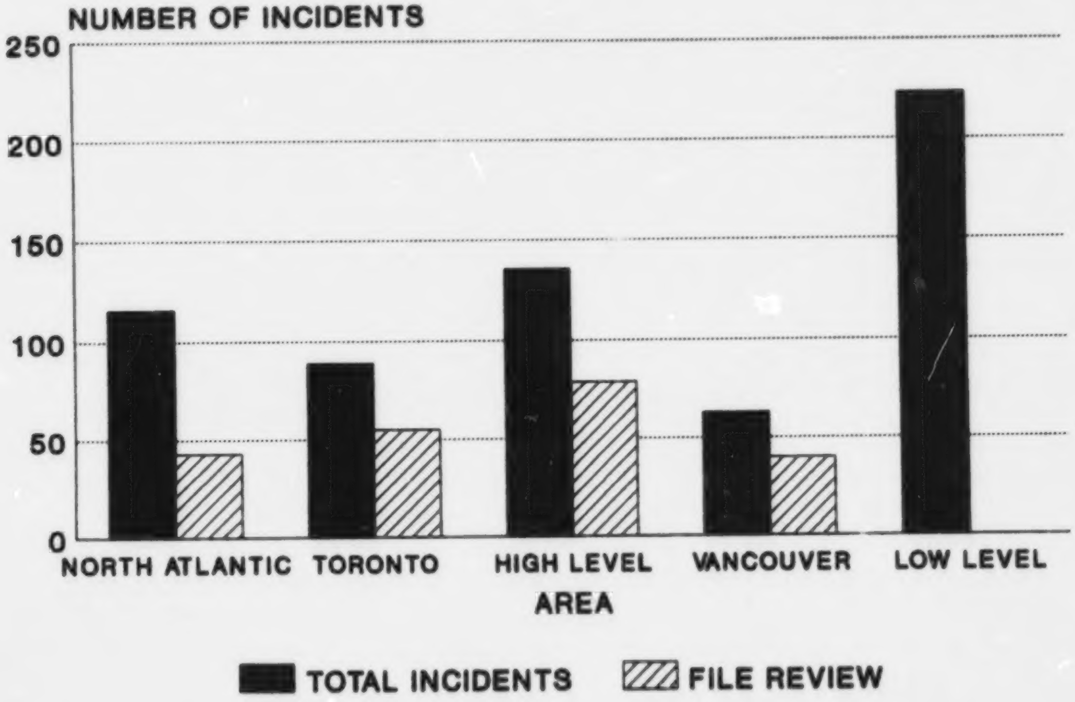
A further subset of the database presented here is based on 217 selected* incidents at Toronto, at Vancouver or in high-level airspace in the years 1985 to 1988. A detailed review of all available information in the files of these incidents was conducted. Safety analysts working on this Special Investigation then assigned possible contributory factors, in accordance with a standard set of factors (which had been developed during a rating session to establish inter-rater reliability). When analysis of these assigned factors is presented, the discussion is limited to this subset of 217 incidents.

---

* The 217 incidents selected for in-depth review by CASB safety analysts occurred at Toronto, at Vancouver, or in High-level airspace, during the period 1985 to 1988, and had been investigated by CASB or Transport Canada (FFB). This sample included over 60 per cent of the incidents at Toronto and Vancouver, 58 per cent of the High-level domestic airspace incidents, and 37 per cent of the North Atlantic incidents in the special data base.

The number of incidents in the subsets described above and the relationships among them are shown in Figure 3-1 below.

FIGURE 3-1
TOTAL INCIDENTS VS. INCIDENTS IN FILE REVIEW



In summary, this report is based upon a special database of 710 occurrences since 1985 where there was a reported loss of separation between two or more aircraft, at least one of which had a MTOW in excess of 5 700 kilograms. These incidents occurred in Canadian airspace or in airspace under Canadian control. A detailed file review of 217 occurrences was conducted by CASB analysts. These 217 incidents occurred in the vicinity of Toronto or Vancouver, or in high-level airspace (domestic or under Canadian control over the North Atlantic). Much of this report is based upon this analysis of these 217 representative occurrences.

3.1 CHARACTERISTICS OF REPORTED INCIDENTS

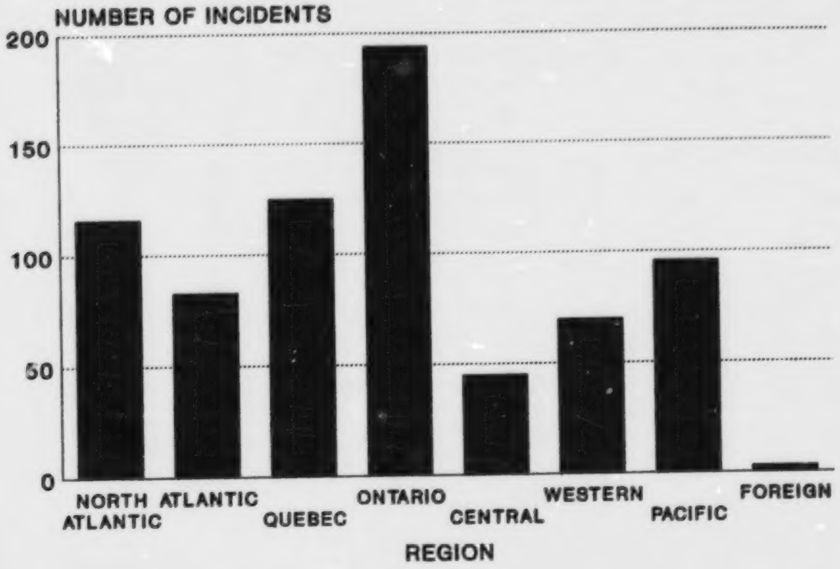
This section describes the overall characteristics of the 710 reported incidents in the special database over the years 1985 to 1988. The description is organized into four groupings -

- Where?	The distribution of incidents geographically.
- When?	The distribution by season, day of week, and time of day.
- Who?	The type of operators involved, flight plans flown, and the types of aircraft being flown.
- Situation?	The airspace, altitude, and flight phase when the incident took place.

3.1.1 Where?

Figure 3-2 shows the distribution of 710 reported incidents across the regions of Canada and the North Atlantic. The largest proportion of incidents took place in the Ontario region (26 per cent). Large numbers of incidents were also reported for the Quebec region (17 per cent) and the North Atlantic (16 per cent). This distribution is believed to approximate the general distribution of IFR traffic in Canada.

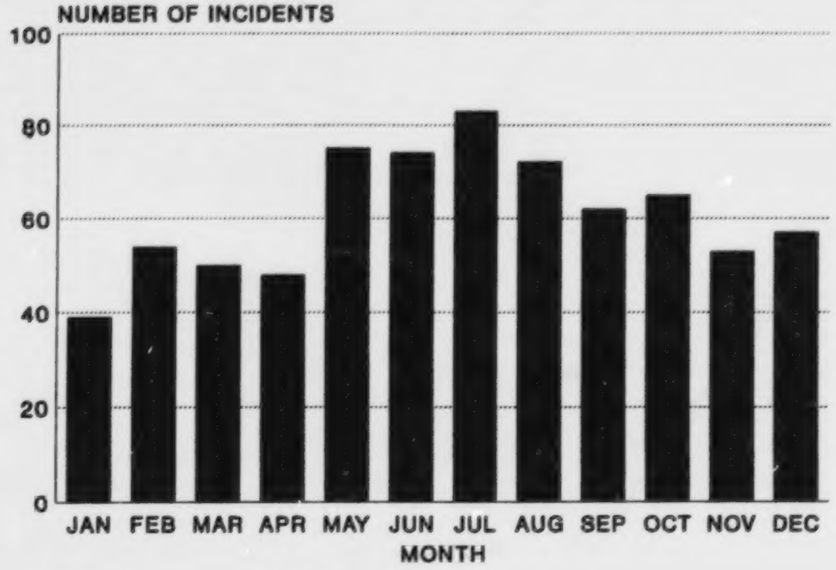
FIGURE 3-2
REPORTED INCIDENTS ACROSS REGIONS



3.1.2 When?

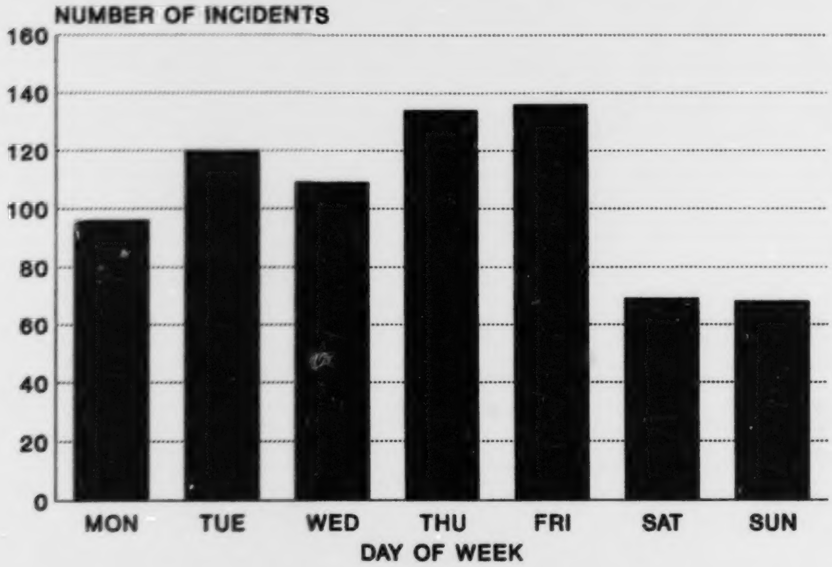
Overall, the 710 reported incidents tend to follow a distribution over time which closely mirrors the traffic pattern. Seasonally, as can be seen in Figure 3-3, incidents peak in July and are at their highest levels from May through to August. This resembles fairly well the traffic distribution. It will be seen later that there are some exceptions to this match between incidents and traffic. Nevertheless, the general observation can be made that more incidents take place when there is more traffic.

FIGURE 3-3
REPORTED INCIDENTS BY MONTH



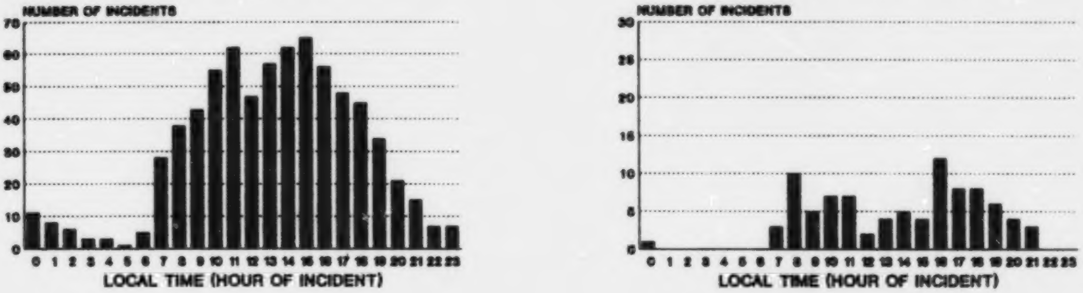
During the week, incidents also tend to follow the traffic pattern (Figure 3-4). The proportion climbs through the week to peak on Friday, and then drops to half that level on the weekend.

FIGURE 3-4
REPORTED INCIDENTS BY DAY OF WEEK



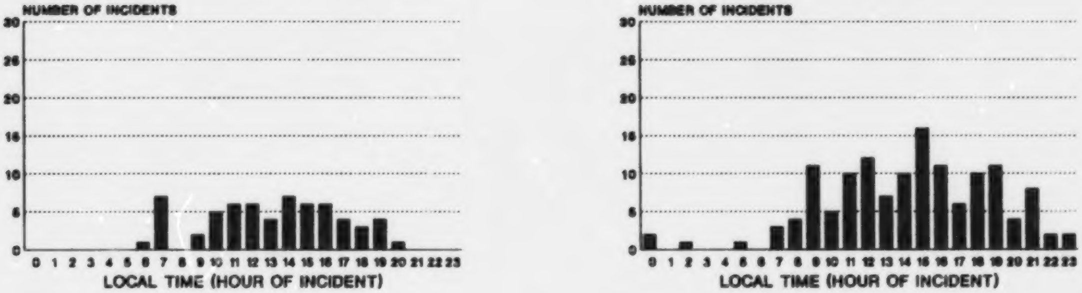
The pattern of occurrences by the time of day is not as clear. Because different types of traffic and traffic in different parts of the country tend to peak at different times of the day, the average pattern is smoothed out. The traffic peaks at Toronto, for example, are quite different from those of traffic over the North Atlantic. Figure 3-5 shows the resultant pattern of incidents.

FIGURE 3-5
REPORTED INCIDENTS BY TIME OF DAY



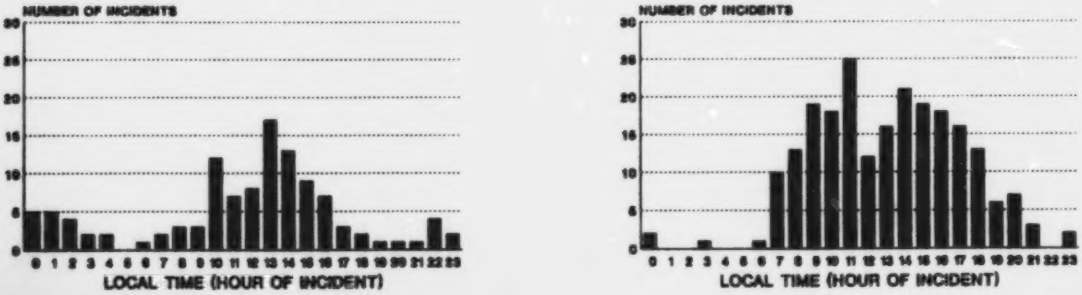
ALL INCIDENTS

TORONTO AREA INCIDENTS



VANCOUVER AREA INCIDENTS

HIGH LEVEL INCIDENTS



NORTH ATLANTIC INCIDENTS

LOW LEVEL INCIDENTS

3.1.3 Who?

The types of operator involved in reported incidents reflect very much the circumstances under which these incidents occur and are reported. In general, recorded incidents occur in controlled airspace to aircraft operating under IFR. This is not to say that VFR aircraft outside of controlled airspace do not come close to one another. Since they tend to operate in far less congested areas, the probability of a close encounter is much less. Also, the reporting requirements (i.e., only aircraft over 5 700 kilograms) and the ability of controllers to detect losses of separation result in a natural bias toward operations involving large transport-category aircraft.

Accordingly, the vast majority of reported incidents involve at least one large aircraft, operated by a scheduled operator (see Tables 3-2 and 3-3). In fact, the largest proportion of incidents involved two such operators (39 per cent). Another common combination involved a charter operator in conflict with a scheduled carrier (13 per cent). Military aircraft were involved in 16 per cent of the reported occurrences.

TABLE 3-2
TYPE OF OPERATOR

TYPE OF OPERATOR	NUMBER OF INCIDENTS	PER CENT
BOTH SCHEDULED	179	39
SCHEDULED/OTHER	100	22
MILITARY/OTHER	73	16
SCHEDULED/OTHER	61	13
CHARTER/OTHER	27	6
OTHER COMBINATIONS	19	4
TOTAL	459	100

(This information was missing for 251 incidents)[**]

[**] Complete data on each occurrence are not always specifically recorded in the occurrence files. If data was not readily available, it was omitted from the analysis. Since there is no apparent pattern to such data omissions, this does not likely affect the results. In each table where the data set is incomplete, a footnote is provided. (**)

Table 3-3 shows the size of the aircraft involved in the occurrences. Most of the aircraft in these incidents are over 50 000 pounds MTOW (22 700 kilograms). Many of the incidents, particularly at high levels, involve two such large aircraft. However, a significant proportion (23 per cent) involve a large aircraft with a small one (5 700 kilograms (12,500 pounds) or less).

TABLE 3-3
AIRCRAFT SIZES

AIRCRAFT SIZES	NUMBER OF INCIDENTS	PER CENT
BOTH LARGE	234	37
LARGE-MEDIUM	110	17
LARGE-SMALL	145	23
BOTH MEDIUM	35	6
MEDIUM-SMALL	110	17
TOTAL	634	100

LARGE	> 50,000 lb maximum take-off weight (MTOW)
MEDIUM	12,500-50,000 lb maximum take-off weight
SMALL	< 12,500 lb maximum take-off weight

(This information was missing for 76 incidents)

Finally, the majority of these incidents involve two aircraft flying IFR (80 per cent). A much smaller percentage (9 per cent) involved a VFR aircraft in conflict with an IFR aircraft. See Table 3-4.

NOTE: Because this study is restricted to reported incidents involving at least one aircraft with a MTOW of 12,500 pounds or more, it is understandable that the proportion of large aircraft, scheduled operators, and aircraft on IFR flight plans are high.

TABLE 3-4
TYPE OF FLIGHT PLANS

FLIGHT PLANS	NUMBER OF INCIDENTS	PER CENT
BOTH IFR	385	80
IFR/VFR	43	9
ONE/BOTH UNKNOWN	55	11
TOTAL	483	100

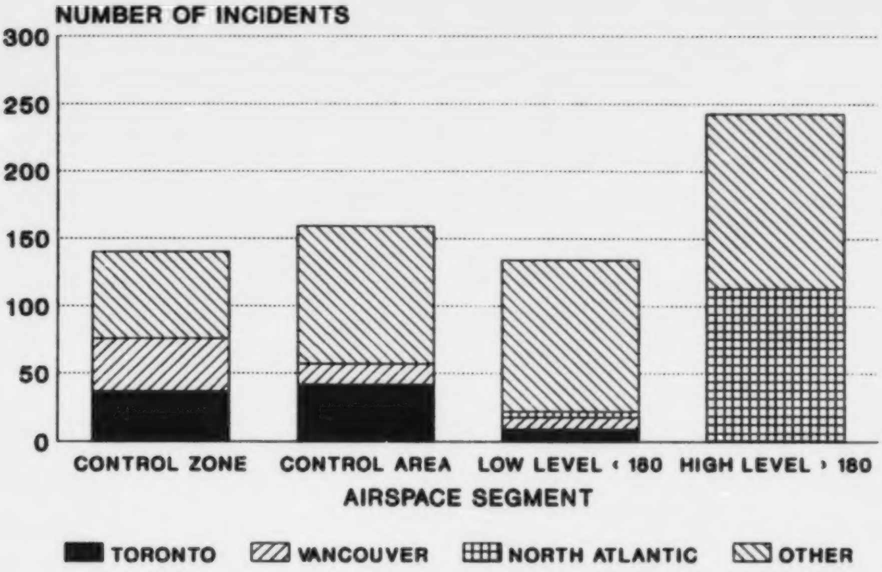
(The type of flight plan was not specifically recorded in 227 incidents.)**

3.1.4 Situation?

Figure 3-6 illustrates the distribution of the reported incidents by airspace segment and altitude. The largest single group of incidents occurred in high-level airspace (36 per cent). This is not surprising, given the other attributes of these incidents, (i.e., large aircraft, scheduled operators, flying IFR). Nearly 17 per cent of all the incidents occurred at high-level over the North Atlantic, and most of these were at altitudes over 30,000 feet.

One-fifth of the incidents took place in terminal control areas, and a similar number were in control zones. Naturally, terminal control area occurrences were almost entirely below 12,500 feet; (by definition, the control area extends only to 12,500 feet).

FIGURE 3-6
AIRSPACE SEGMENT

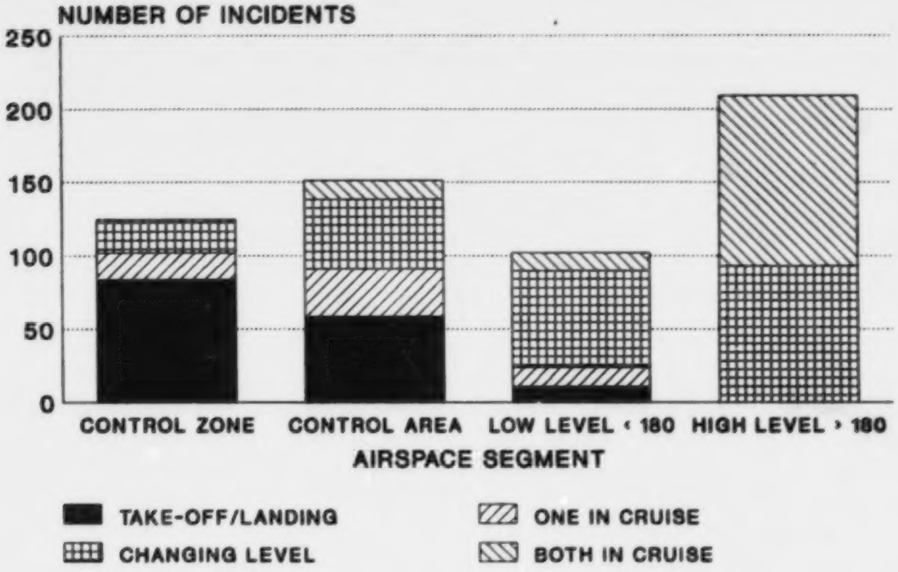


(Control area refers to the Terminal Control Area)

The flight phase is compared to the airspace in which the incident took place in Fig 3-7. The majority of the high-level incidents involved two aircraft in level cruise. However, a significant proportion (44 per cent) involved one aircraft changing altitude. Notably, there were far fewer incidents with both aircraft changing altitudes.

The Terminal Control Area incidents involved one aircraft in the landing or take-off phases (mainly landing) and another in low-level cruise, climbing to cruise, or descending from cruise. Control zone incidents were similar but with more incidents involving both aircraft in the landing or take-off phases.

FIGURE 3-7
AIRCRAFT FLIGHT PHASE



(Control Area refers to the Terminal Control Area)

3.1.5 Summary

In summary, the distribution geographically and over time of the 710 reported incidents generally matches traffic patterns fairly closely. Reflecting the nature of the incident reporting system, the incidents normally involve at least one scheduled airline, flying a large aircraft under IFR.

3.2 RISK OF COLLISION

Clearly, it is very important to determine just how dangerous were the reported incidents. Any loss of separation is an indication of a breakdown in the system designed to keep aircraft apart and could potentially point to a safety deficiency. However, momentary small encroachments into the safety buffer between aircraft are to be expected. For example, due to discrepancies in setting clocks, longitudinal separation over the North Atlantic may be reduced from 10 minutes to 9 minutes; or as aircraft reduce their speed on final approach in preparation for landing, the normal longitudinal separation with a following aircraft may be reduced from three miles to 2.8 miles. In either case, corrective action should be initiated as soon as the discrepancy is noted to restore the required separation. Incidents where the separation was grossly reduced or where emergency actions by one or other aircraft were required to avoid actual collision are obviously far more serious.

Unfortunately, attempting to quantify the degree of risk in a particular incident is extremely difficult. Situations at the two extremes are fairly easy to assess. Occurrences involving collisions or violent, last instant evasive manoeuvres are clearly the most disconcerting. Fortunately, very few such incidents take place. (There have been no actual midair collisions involving an aircraft over 5 700 kilograms in Canada since 1970, when a light aircraft collided with a Viscount near Vancouver.) Similarly, very minor incidents can fairly easily be categorized. The difficulty lies in between. The degree of risk involved is a function of the relative paths of the two aircraft and their relative velocities. In addition, the type of airspace and the kind of control being applied all must be taken into account.

For these reasons, it is not possible, or wise, to present a single classification of risk for these data. Two components of the risk are presented - whether or not evasive action was taken, and the separation distance between two aircraft at closest approach. In addition, a classification of some of the incidents into risk categories based on a method developed by the Federal Aviation Administration (FAA) (described in Annex B to this chapter) is presented.

The data presented below indicate that the majority of the incidents reported did not represent extremely serious events but were more of a technical loss of separation. However, there was a significant minority where the situation was very serious.

Table 3-5 shows the proportions of incidents where one or more of the aircraft concerned initiated a change of direction in their flight path to avoid another aircraft. In one-fifth of the incidents where these data are reported, such action was taken. It should be noted that such direction changes were not necessarily last-instant, violent actions. In some cases they represent the prudent action of a pilot some time in advance of the close approach of the other aircraft concerned.

TABLE 3-5
EVASIVE ACTION INITIATED BY PILOT

EVASIVE ACTION	NUMBER OF INCIDENTS	PER CENT
INITIATED	103	19
NOT INITIATED	436	81
TOTAL	539	100

(This information was missing for 171 incidents.)[**]

Data on just how close the aircraft came are, unfortunately, not always provided in the database. Out of the 710 incidents, some 411 gave information on the vertical separation of the aircraft and only 249 reported the horizontal separation. However, it is reasonable to assume that, in the very close encounters, the separation would generally have been reported, so that the data on the numbers of such occurrences are believed to be realistic.

Table 3-6 presents data for 219 incidents in which both the horizontal and vertical separation were reported. It can be seen that, in most of these reported cases (71 per cent), the aircraft were at essentially the same altitude, with less than 500 feet vertical separation. Of these, 14 per cent had less than 1/2 mile horizontal separation, while 43 per cent were within 2.5 miles.

TABLE 3-6
VERTICAL AND HORIZONTAL SEPARATION

VERTICAL SEPARATION		
HORIZONTAL SEPARATION	NUMBER OF INCIDENTS	PER CENT
LESS THAN 500 FEET		
LESS THAN 1/2 MILE	30	13
1/2 TO 2 1/2 MILES	64	29
OVER 2 1/2 MILES	61	28
SUB-TOTAL	155	70
500 TO 1000 FEET		
LESS THAN 1/2 MILE	6	3
1/2 TO 2 1/2 MILES	22	10
OVER 2 1/2 MILES	6	3
SUB-TOTAL	34	16
OVER 1000 FEET		
LESS THAN 1/2 MILE	5	2
1/2 TO 2 1/2 MILES	8	4
OVER 2 1/2 MILES	17	8
SUB-TOTAL	30	14
TOTAL	219	100

(This information was missing for 491 incidents.)[**]

For incidents in 1987 and 1988, where a Fact Finding Board was held, an assessment of the risk of collision had been made by Transport Canada. This assessment was available for some 207 incidents; one of four risk categories was assigned to each of these incidents (no risk, technical loss of separation, critical loss of separation, and risk of collision). The method used for this assignment is based on an approach developed by the FAA. (A description of the method is provided in Annex B to this chapter.)

This classification attempts to take account of the circumstances surrounding a particular incident. The results are shown in Table 3-7. Overall, 17 per cent of the incidents were judged to have represented a real risk of collision. A further 18 per cent were felt to have involved a critical loss of separation. However, as indicated at the outset of this discussion above, most of the incidents were less serious, usually involving a momentary small encroachment into the safety buffer. Almost half (43 per cent) were judged to be technical losses of separation only, while a further 13 per cent were classified as representing no risk at all.

TABLE 3-7
RISK CLASSIFICATION

DEGREE OF RISK	NUMBER OF INCIDENTS	PER CENT
RISK OF COLLISION	36	17
CRITICAL LOSS	37	18
TECHNICAL LOSS	89	43
NO RISK OF COLLISION	26	13
VFR HAZARD	6	3
NOT RATED	7	3
MISSING	6	3
TOTAL	207	100

3.3 COMPARISON WITH AIRCRAFT MOVEMENTS

To identify whether any airport appears to have more incidents than would be expected, a comparison analysis was done with the numbers of aircraft movements (landings and take-offs) at each airport. Although such comparisons cannot definitively determine if the number of incidents at an airport is high, it can certainly indicate where further study may be warranted.

Incidents in the database where the aircraft involved were landing or taking-off from an airport were assigned to that airport. In addition, incidents where one or more of the aircraft involved were destined for or originated at that airport, and the incident took place in proximity to the airport, were also included. The number of incidents at a particular airport were then tabulated separately for the four years included in this study. (Obviously, based on the method used, high-level incidents were excluded). These data were then combined with data on aircraft movements at all airports with a control tower. Movements were also obtained for airports without towers, where an incident had been reported.

The resultant data are plotted in Figure 3-8. The data for each year are shown separately. For this reason, each airport appears four times on the graph. To assist in interpretation, a line has been drawn which represents the calculated best fit to the data. (Technically, a polynomial regression was performed).

In general, the number of incidents increases as does the number of movements. It also appears that the rate of increase grows with larger numbers of movements. In fact, the fitted regression line suggests that the number of incidents increases approximately as the square of the number of movements. This observation is remarkably similar to a theoretical and simple model of incidents resulting from traffic congestion. If the aircraft in the airspace around an airport are treated as if they were moving randomly, the expected number of close encounters would be a function of the square of the number of aircraft. Of course, aircraft do not fly randomly. Their flight paths and the procedures governing them are designed to keep aircraft apart and to continue to do so as the traffic volume increases. These data suggest that, despite these efforts, the number of incidents is more than proportionately higher at busy airports.

Looking at the individual airports, it can be seen that, for both Toronto and Vancouver, the numbers of reported incidents are higher than would be expected given the number of movements. In addition, the incident data for Dorval and Ottawa are above the national trend line that correlates incidents and aircraft movements. Of course, this analysis cannot take full account of all the idiosyncratic characteristics at each airport which may contribute to the observed incidents.

Figure 3-8

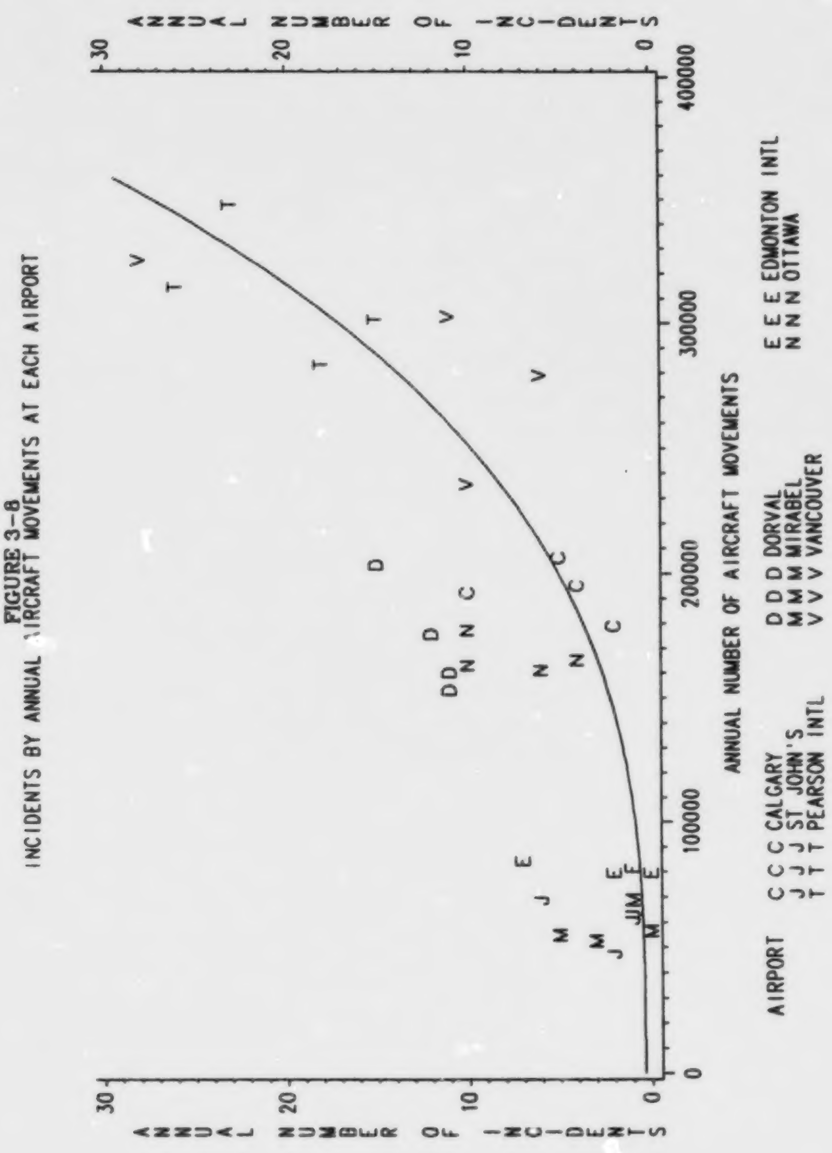


FIGURE 3-8
INCIDENTS BY ANNUAL AIRCRAFT MOVEMENTS AT EACH AIRPORT
ANNUAL NUMBER OF INCIDENTS
0
10
20
30
0
100000
200000
300000
400000
ANNUAL NUMBER OF AIRCRAFT MOVEMENTS
AIRPORT
C C C CALGARY
J J J ST JOHN'S
T T T PEARSON INTL
D D D DORVAL
M M M MIRABEL
V V V VANCOUVER
E E E EDMONTON INTL
N N N OTTAWA

3.4 FACTORS CONTRIBUTING TO INCIDENTS

For each of the 217 incidents selected for in-depth review in this Special Investigation, a CASB analyst examined all the information available to identify the safety-related factors which may have contributed to the incident. While no concrete criteria were established as such, each of the analysts involved did participate in a standardization session to ensure consistency in the process. Nevertheless, it must be understood that the process was largely subjective, based on the analysts' collective experience.

Since many of these incidents were the object of a Transport Canada FFB, the factors assigned by the CASB safety analyst were usually similar to those assigned by the FFB. However, the objective of this file review was somewhat different than that for the FFBs; therefore some assigned factors differ from those provided by Transport Canada. In particular, differences were noted with respect to the adequacy of available supervision at the time of the occurrence - whether cause-related or not; whereas FFBs record this data, their cause-factor system does not address supervisory issues. Because the CASB staff analysts did not use the same analytical methods as the investigators of Transport Canada FFBs, differences exist with respect to the assessment of the effects of staffing and workload-related issues in particular. While the methodology used is not wholly consistent with Transport Canada's methods, this methodology did provide a standard basis for examining CASB occurrence reports concurrently with Transport Canada FFB.

The factors assigned were organized into six basic groups - Operations, Staffing, Training, Human Performance, Equipment, and Environment. Table 3-8 shows the combined results for all incidents reviewed. The most commonly noted group of factors was Human Performance which accounted for almost half the total factors assigned and was present in the vast majority of files reviewed. Factors related to Operations and Staffing accounted for most of the remaining factors assigned, with each accounting for slightly under a quarter of the total. The remaining three groups did not account for a large number of the factors found to be contributing to the occurrences of the file review of this Special Investigation.

TABLE 3-8
FILE REVIEW BY FACTOR GROUP

FACTOR GROUP	NUMBER OF INCIDENTS AFFECTED	% OF INCIDENTS AFFECTED
HUMAN PERFORMANCE	192	88
OPERATIONS	95	44
STAFFING	94	43
EQUIPMENT	20	9
TRAINING	15	7
ENVIRONMENT	4	2

The most frequent individual factors for each of the three main factor groups are shown in Table 3-9. Within the Human Performance group, three factors stand out: Planning, Judgement, and Inattention. These three account for almost 60 per cent of the Human Performance factors assigned. For the Operations-related factors, Procedures were the most commonly cited problem. Coordination was also frequently found, and, less often, Poor Supervision and Communications contributed. Finally, within the Staffing-related factors, the fact that a Working Supervisor was identified in 72 occurrences is significant. The next most common factor in this group was Inadequate Staffing.

TABLE 3-9
INDIVIDUAL FACTORS ASSIGNED

INDIVIDUAL FACTORS*	FREQUENCY OF FACTOR ASSIGNMENT	PER CENT WITHIN FACTOR GROUP
HUMAN PERFORMANCE		
PLANNING	88	22
JUDGEMENT	75	19
INATTENTION	73	18
WORKLOAD	35	9
REMAINING FACTORS	130	32
OPERATIONS		
PROCEDURES & PRACTICES	52	38
COORDINATION	30	22
POOR SUPERVISION	17	13
COMMUNICATIONS	16	12
REMAINING FACTORS	20	15
STAFFING		
WORKING SUPERVISOR**	72	59
INADEQUATE STAFFING	20	16
REMAINING FACTORS	30	25

* More than one individual factor within a factor group could have been assigned to a single incident.

** In the case of "working supervisors", the analysts did not necessarily establish a cause and effect relationship between the fact that the supervisor was working and the occurrence. However, in view of current staff shortages, the analysts recorded the fact of a working supervisor in the belief that working supervisors cannot provide as effective supervision to their team.

In general, the pattern of observed factors is very similar for the different airspace and airports included in this review. Table 3-10 shows the breakdown of the major contributing factors into the airport or airspace concerned. The predominance of the Human Performance, Operations and Staffing factors is consistent for each subgroup. While there are some differences in individual factors, the general pattern remains the same.

TABLE 3-10
FACTORS ASSIGNED BY AREA

INDIVIDUAL FACTORS	VANCOUVER AREA		TORONTO AREA		DOMESTIC HIGH LEVEL		NORTH ATLANTIC	
	N	%	N	%	N	%	N	%
HUMAN PERFORMANCE								
PLANNING	16	13	17	9	33	12	22	18
JUDGEMENT	13	11	19	10	32	12	11	9
INATTENTION	6	5	12	6	39	14	16	13
WORKLOAD	6	5	10	5	11	4	8	7
REMAINING FACTORS	18	16	43	24	44	17	25	21
OPERATIONS								
PROCEDURES	14	12	13	7	18	7	7	6
COORDINATION	10	8	7	4	8	3	5	4
POOR SUPERVISION	5	4	0	0	7	3	5	4
COMMUNICATIONS	1	1	6	3	7	3	2	2
REMAINING FACTORS	6	6	5	3	7	3	2	2
STAFFING								
WORKING SUPERVISOR	11	9	25	13	30	11	6	5
INADEQUATE STAFFING	6	5	5	3	6	2	3	2
REMAINING FACTORS	3	3	5	3	13	5	9	8

(N = number of incidents)
(% = per cent of all factors assigned for area)

Looking in more detail at the Human Performance group of factors, the planning factor is found in all areas but is higher in the North Atlantic (18 per cent) and lower at Toronto (9 per cent). Judgement errors are found consistently in all areas. Inattention on the part of the air traffic controller is more of a problem in the high-level airspace (14 per cent Domestic and 13 per cent North Atlantic) than at Vancouver and Toronto (5 and 6 per cent). This presumably is related to the nature of the activity at the airports versus the high-level airspace. As will be shown later, there is a strong relationship between the Pace Level (degree of "busyness") and Inattention errors.

In the Operations area, Vancouver stands out for Procedure errors, with 12 per cent (versus 7 per cent at Toronto) and also for Coordination problems with 8 per cent (versus 4 per cent at Toronto). While these numbers are small, these relatively frequent observations may suggest operational weaknesses at Vancouver.

With respect to Staffing factors, there is some variation in the involvement of Working Supervisors in the files reviewed. This factor appears to be particularly acute at Toronto (13 per cent), but less so for the North Atlantic (5 per cent). This may be a function of workload and complexity, in that the need for over-the-shoulder monitoring may be critical when the situations develop more rapidly, as they do at Toronto.

3.5 SAFETY ISSUES

Prior to and during this investigation, a number of potential safety issues were identified. Many of these issues are not amenable to objective analysis based on the occurrence record, either intrinsically or because of a lack of appropriate data. This section examines two related issues - workload and traffic congestion - from the occurrence record as described in this chapter. To the extent possible and reasonable, the data are analysed for the light they can shed on these issues.

3.5.1 Workload vs Error Rate

It has been suggested that the ATC system is understaffed for the current traffic levels and that this leads to excessive workload demands on controllers and thereby to increased errors. This section examines the evidence to determine whether a higher workload contributes to more errors.

This review of the 217 incidents described above does offer some evidence that the workload on individual controllers may have contributed to particular incidents. "Workload" was assigned as a contributing factor in 35 incidents. "Inadequate staffing" was assigned in 20 incidents. In response to a need to cut back on resource requirements, Transport Canada required that first-line supervisors fill operational control positions for up to 50 per cent of the time. The number of times that "working supervisor" was noted (72 or one third of all the incidents) is an indication of problems resulting from inadequate staffing. Weaknesses in the working supervisor concept have already been the subject of a CASB Recommendation (CASB 88-18) which sought immediate steps to provide an increased operational overview at Toronto during busy traffic periods.

The impact of workload can also be examined by looking at the indirect effects. The factors assigned were compared to the Pace Level of the work of the controller at the time of an incident. (See Annex A to Chapter 5, Staffing, for definitions of the Pace

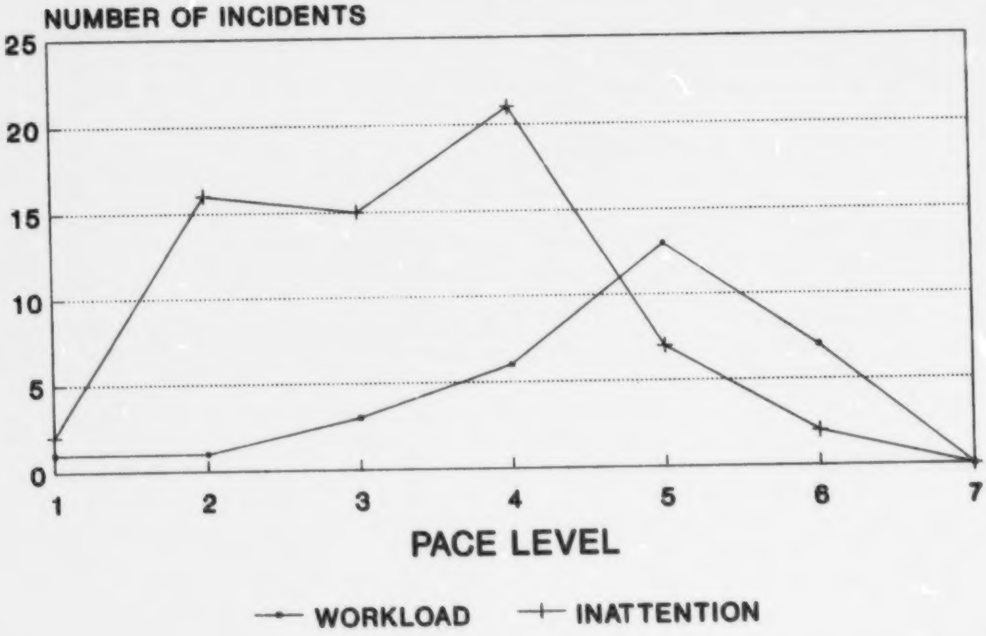
Levels.) Some of the results are shown in Figure 3-9. In general, the factors assigned by the analysts do not change markedly as the Pace Level increases; however, there were some factors which did vary with Pace Level:

- Not surprisingly, the workload factor is cited far more frequently at high Pace Levels.
- Inattention, on the other hand, was assigned as a contributory factor more often at low Pace Levels.

All other factors show no significant variation.

Chapter 5 contains a more complete discussion of workload and staffing factors.

FIGURE 3-9
FACTORS ASSIGNED AND PACE LEVEL



3.5.2 Traffic Congestion

This issue is related to workload, in that increased congestion can itself lead to increased workload on [illegible]

whether congestion leads to a number of breakdowns in safety, either through human or equipment shortcomings.

As shown earlier in Figure 3-8, there is a fairly clear relationship between traffic volume at an airport and the number of reported incidents at that airport. Furthermore, the relationship is not linear - increases in traffic result in more than proportional increases in incidents. While this may appear to be an expected result, the systems, procedures and resources at busier airports are supposed to be able to handle the higher volume and complexity of the traffic. Ideally, if the allocation of resources between large and small airports is proportional to traffic, there should be no difference in the rate of incidents. While this may not be a realistic expectation, the system should adjust to the traffic differences to keep the increase in incidents to a minimum. When we compare airports having different traffic densities, this does not seem to be the case.

Does the same observation hold for increased traffic at a single airport? Certainly there appear to have been increases in incidents reported over the last four years as traffic has increased. However, a number of elements may confound the relationship. There have been significant changes in incident reporting systems over the same time period which has led to an increase in reported incidents. There has also been considerable media attention on the issue, initially in the U.S.A. and more recently in Canada. As a result, these confounding elements may have contributed to the increase in the number of incident reports without a real increase in the number of actual incidents.

Again the evidence to be drawn from the incident record provides some support for the idea that increased traffic volume leads to greater numbers of incidents, but the picture is by no means clear.

3.6 OBSERVATIONS

1. There were 710 losses of separation reported over the four-year period, 1985 to 1988, which fit the definition for this study.

2. The largest proportion of incidents occurred in Ontario region.

3. The frequency of incidents peak in July and are at their highest levels from May through August.

4. The frequency of incidents generally climbs through the week to peak on Friday, then drops to half the Friday level on weekends.

5. The vast majority of reported incidents involve at least one large aircraft (maximum take-off weight of more than 22 700 kilograms), operated by a scheduled operator, flying under IFR.

6. There have been no midair collisions in Canada since 1971 involving aircraft over 5 700 kilograms maximum take-off weight.

7. Evasive action (but not necessarily at the last instant) was reported in 19 per cent of the incidents.

8. Over half of the 207 incidents for which Transport Canada assigned a degree of risk were classified as technical losses of separation or represented no risk of collision at all. Transport Canada judged that there was a risk of collision in less than one-fifth of these occurrences.

9. The frequency of incidents increases approximately as the square of the number of movements. Toronto and Vancouver are at the upper end of the data in both movements and incidents.

10. The most common group of cause factors assigned to the 217 incidents during the file review phase was Human Performance; Operations and Staffing accounted for most of the remaining factors assigned.

11. Planning, Judgement, and Inattention account for almost 60 per cent of the Human Performance factors assigned. Procedures and Operating Practices was the most common Operations factor, followed by Coordination. The most common Staffing factor was Working Supervisor; the next most common factor was Inadequate Staffing.

12. Workload-related errors occur more frequently at high Pace Levels, while Inattention-related errors occur more frequently at the lower Pace Levels.

DISCREPANCIES BETWEEN THE ATS SPECIAL INVESTIGATION DATABASE AND THE CASB CAIDS DATABASE

Of the 710 incidents in the ATS Special Investigation database, 513 are also found in the CASB Canadian Accident/Incident Data System (CAIDS) database. However, 197 incidents were not included in the CAIDS database.

Disposition:

175	Transport Canada Fact Finding Boards. Almost half (48%) of all the Fact Finding Boards of loss of separation incidents were not recorded in CAIDS. This is a serious shortcoming in CASB's data collection.
6	Not investigated further by any agency. There was considered to be no ATS involvement by Transport Canada; CASB was advised of the occurrence but did not investigate.
3	ATS infractions.
4	Air Canada Air Miss Reports.
3	Reported to the Canadian Forces (for their action).
2	Transport Canada Preliminary Reports indicated that CASB would investigate, but CASB did not.
1	Gross Navigation Error Report.
1	Investigated by Transport Canada, Chief Flight Service Station Operations.
1	Referred to FAA.
1	Investigated by an American ARTCC.

There has been a decrease each year since 1985 in the number of loss of separation incidents not included in the CAIDS database. However, in 1988 there were still 21 incidents which were included in the ATS Special Investigation but were not found in the CAIDS database. Twenty of these were Fact Finding Boards; one was to be investigated by CASB according to the Transport Canada Preliminary Report but was not investigated.

REGION	1985	1986	1987	1988	TOTAL
Atlantic	4	8	4	2	18
Quebec	20	21	14	5	60
Ontario	19	10	12	0	41
Central	11	6	4	9	30
Western	6	4	7	2	19
Pacific	14	7	5	3	29
TOTAL	74	56	46	21	197

Quebec region and Ontario region have the highest number of loss of separation incidents not included in the CAIDS database (60 and 41). However, there has been a steady decline in the number in the Quebec region since 1986; in 1988, there were less than half the number there were in 1987. In 1988, the number not included in the Ontario region dropped to zero. Only Central region had an increase in the number not included in CAIDS in 1988.

RISK OF COLLISION

Effective 01 January 1989, the following definition of risk of collision was adopted by the Mid-Air Collision Avoidance Committee, Transport Canada (correspondence, 1989-01-10).

The lateral/longitudinal separation and the vertical separation are determined, and points are assigned to each, depending on how close the aircraft were to one another. The higher the number of points, the closer together the aircraft were. The lateral/longitudinal and vertical separation points are then summed; the degree of risk of collision is based on this sum. The tables below, which show the number of points for specific separation distances, were obtained from Transport Canada.

RISK OF COLLISION

The following tables are to be used to determine the severity of an ATS operating irregularity. When the vertical and horizontal spacing between two IFR aircraft has been determined by electronic measurement (S-Radar) or by controller/pilot reports, refer to the following tables to ascertain points to be assessed and the severity of the operating irregularity.

LATERAL/LONGITUDINAL SEPARATION

EN ROUTE OPERATING IRREGULARITY NON-RADAR	POINTS
80% of the separation required	1
70% to less than 80% of the separation	3
60% to less than 70% of the separation	5
50% to less than 60% of the separation	7
40% to less than 50% of the separation	8
20% to less than 40% of the separation	9
Less than 20% of the separation	10

EN ROUTE OPERATING IRREGULARITY - REMOTE RADAR SOURCE	
8 miles to less than 10 miles	1
7 miles to less than 8 miles	2
6 miles to less than 7 miles	3
5 miles to less than 6 miles	4
4 miles to less than 5 miles	5
3 miles to less than 4 miles	7
2 miles to less than 3 miles	8
1 mile to less than 2 miles	9
Less than 1 mile	10

EN ROUTE OPERATING IRREGULARITY - NON-REMOTE RADAR SOURCE

4 miles to less than 5 miles	1
3½ miles to less than 4 miles	2
3 miles to less than 3½ miles	3
2½ miles to less than 3 miles	4
2 miles to less than 2½ miles	5
1½ miles to less than 2 miles	6
1 mile to less than 1½ miles	7
½ mile to less than 1 mile	8
Less than ½ mile	10

TERMINAL OPERATING IRREGULARITY

2½ miles to less than 3 miles	1
2 miles to less than 2½ miles	3
1 3/4 miles to less than 2 miles	5
1½ miles to less than 1 3/4 miles	7
1 mile to less than 1½ miles	8
½ mile to less than 1 mile	9
Less than ½ mile	10

VERTICAL SEPARATION

FL290 AND BELOW

900 feet to less than 1000 feet	2
800 feet to less than 900 feet	4
700 feet to less than 800 feet	6
600 feet to less than 700 feet	8
500 feet to less than 600 feet	9
Less than 500 feet	10

ABOVE FL290

1500 feet to less than 2000 feet	2
1000 feet to less than 1500 feet	3
700 feet to less than 1000 feet	5
600 feet to less than 800 feet	8
500 feet to less than 600 feet	9
Less than 500 feet	10

SEVERITY OF AN OPERATING IRREGULARITY

The severity of the operating irregularity is the sum of the lateral/longitudinal and vertical points as follows:

Risk of collision	18-20 points
Critical loss of separation	14-17 points
Loss of separation (Technical)	13 points of less

Note

The Transport Canada Mid-Air Collision Avoidance Committee also decided that all pilot-initiated reports involving evasive action will be classified as risk of collision .... 18-20 points.

CHAPTER 4

EQUIPMENT

4 INTRODUCTION

The provision of a safe, orderly, and expeditious flow of air traffic requires an air navigation infrastructure as well as a system for the provision of air traffic services. Given the rapid increases in air traffic levels world-wide over the past 20 years, the demands on the Canadian Air Navigation System have been enormous. To maintain safety in the air navigation system, vast sums have been spent and vast sums will be required in order to meet Canada's evolving requirements. Consequently, the Air Navigation Directorate of the Department of Transport has developed a Canadian Airspace Systems Plan (CASP) to guide the revamping of the system. The older equipment in use today, particularly the radar systems and displays, are no longer able to meet operational demands. Therefore, at the heart of this Plan is the Radar Modernization Project, the installation of new state-of-the-art radars at 41 locations at a cost of $810 million.

Although the Special Investigation did not interview any personnel of the Technical Services Branch, indications are that, from an operational point of view, preventive and repair maintenance of current equipment is not creating operational or safety problems. Several controllers spoke favourably of the level of service being provided in maintaining the equipment, and no reports were received of significant equipment unserviceabilities or excessive down-time.

On the other hand, surprisingly few of the controllers or managers interviewed expressed particular excitement about the increased technical capabilities that will be available as the various elements of the CASP are implemented. Furthermore, dissatisfaction was expressed with respect to the lack of ongoing enhancement of capabilities of currently deployed systems. It is understood that there is a backlog of approximately 400 unsatisfactory condition reports and equipment change proposals for which Transport Canada does not have the engineering capability to make the required operational improvements.

Some controllers also had concerns over the authority for configuration control and queried whether centralized configuration control is necessary to the extent that it is being practised today. In some cases, concern was also expressed over the potential impact of limited spares availability vis-à-vis major unserviceabilities or any needed expansion of capabilities.

Equipment was found to be contributory to an ATC operating irregularity in only 20 (9 per cent) of the 217 occurrence files reviewed. Similarly, cause factors assigned by FFBs determined that equipment-related problems contributed to the 362 occurrences in less than 10 per cent of the occurrences. Nevertheless, it is believed that a higher proportion of ATS occurrences have equipment-related contributory factors than the recorded data would indicate.

The focus of this chapter is on the safety-related aspects of equipment that became apparent during the file review and field survey phases of this Special Investigation. The problems discussed within this chapter, however, must be seen in the larger context of the overall equipment and facility upgrade programs of the Canadian Airspace Systems Plan.

4.1 AIRPORT CONTROL TOWERS

4.1.1 General

To facilitate visibility over the airport's entire surface, control towers need to be relatively high and relatively centrally located. Increasing air traffic volume over the past 20 years has necessitated significant increases in tower staff levels - particularly at Canada's largest airports. For example, ground control now requires two positions at LBPIA, and coordinators are now often necessary to help alleviate the pressures of communications between various controllers. In addition, extra equipment has often had to be added to facilitate the controllers' tasks. Management of available work space in control towers has necessitated great innovation to minimize the effects of overcrowding.

Some airport controllers believe they are being asked to work with old and outdated equipment vis-à-vis that employed by their colleagues in the ACCs. For example, in the control tower at LBPIA, controllers complained about the quality of the radar presentation (e.g., it lacks Joint En Route Terminal System (JETS) data blocks) vis-à-vis the presentations in the Centres.

4.1.2 Work Stations

All tower controllers work at consoles, on and in which are mounted various pieces of equipment necessary to carry out their duties. Over years of trial-and-error, an acceptable level of efficiency has been attained in the layout of controller consoles. In recent years, ergonomic factors have been taken into account in the design of consoles, such that, the more recent the installation, the more effective the equipment. Unfortunately, however, many airport control consoles use a mixture of old equipment in a less than efficient layout.

In addition to the basic wind and altimeter instruments, telephones and radio controls - the basic tools of an airport controller - a tower work position now often includes a variety of high-tech instruments, controls, and video screens. For example, radar screens, Air Traffic Information Service (ATIS) recording equipment, a variety of airport lighting selectors and runway incursion warning systems now complement the controllers' more basic tools. Managers and technicians in some units have been forced to suspend equipment from the ceilings or to stack it on the window ledges. Ingenuity will be required to accommodate the next generation of RAMP monitoring equipment slated for installation over the course of the 1990s.

Vancouver and Toronto airport controllers in particular found much to criticize in their units; these towers have clearly outgrown their capacity to accommodate either the increased staff or any new equipment. At both airports, equipment innovations and evolution over the last 10 to 15 years have left consoles crowded and badly placed. At Toronto for example, the only source of Mode C altitude information, a slaved Cathrode Ray Tube (CRT) display of the Arrival IM (Indicator Module), is suspended from the ceiling between two airport controller positions. High ambient light and reflections have made this display extremely difficult to see during the day shifts - unless the controllers move physically from their operating positions. Several controllers complained of the constant need for "rubber-necking" to read instrumentation, scan displays, and look outside the tower. In one FFB report, it was noted that the controller had to move 15 feet from his work station to visually check the Airport Surface Detection Equipment (ASDE) display. It is understood that preliminary planning is currently underway to improve the layout of the tower cabs at both Toronto and Vancouver.

As further evidence of the space limitations imposed in control towers, the Confidential Aviation Safety Reporting Program has received reports from tower controllers expressing their concern over the location of the Operational Information Display System (OIDS) screen and the size of the lettering on the screen. Because of the fixed location of the screen, controllers complain that they are unable to read the OIDS display without moving from their control position; providing timely response to requests for information while simultaneously monitoring aircraft activities can thus become a problem.

In sum, the lack of integration of information requires tower controllers to monitor several displays and information sources to make critical decisions, such as the spacing between landing and departing aircraft under IMC.

4.1.3 Visibility Problem On The Airport

The Airport Surface Detection Equipment (ASDE), a short-range, high-resolution radar, is currently being installed at six Canadian airports. ASDE will help minimize the risk of collision between aircraft, and between vehicles and aircraft operating on the manoeuvring areas of the airport during periods of reduced visibility. Such systems currently are functional at Toronto, Montreal and Vancouver.

Feedback from airport controllers using ASDE indicates that resolution of vehicle targets and movement at a distance from the antenna is poor. At Toronto, several critical points on the airport are reported to be not visible to ASDE at all, and there have been complaints of system degradation in heavy rain. However, according to Transport Canada officials, no such problems have been reported to Transport Canada concerning ASDE performance for over a year when corrective action was initiated. Since the need for ASDE is greatest during periods of reduced visibilities, any remaining such problems in ASDE performance should be addressed to obtain the full benefit of this equipment.

4.2 THE AREA CONTROL CENTRE

4.2.1 General

In the 1970s and 80s, seven new ACCs were built. These new facilities are purpose-built, modern, climate-controlled, and are generally spacious. While a few controllers complained about lighting, air quality, and even temperature control, the physical work environment in the ACCs was found by the investigators to be generally satisfactory.

In 1987, a study was conducted in the Montreal Centre on the quality of working conditions.[3] Among other things, this study addressed the physical working environment in the Centre. Sixty per cent of the respondents complained about air circulation, the lack of natural lighting, and the ambient temperature. They described the physical environment as being that of a "bunker" or a "prison." During the field survey, the Special Investigators did not encounter such a negative response. Indeed, it is understood that nearly $5 million is currently being spent on upgrading the physical facilities of the Montreal ACC.

4.2.2 Consoles

During the revamping of the ACCs, IFR work stations were carefully studied at the regional and national levels, resulting in a relatively modern, well-planned layout. These work stations integrate the requisite radar display, communications systems, data boards, and other information display systems. They are generally equipped to accommodate at least two controllers operating a particular IFR sector and are generally located such that adjoining sectors have adjoining work stations within the subunit or specialty.

Notwithstanding the relative spaciousness of these new ACCs, increasing traffic levels have placed a premium on available space within the ACCs. Consequently, the high noise levels generated by a particularly busy sector can create distractions for adjacent sectors or subunit/specialties. There was some suggestion from controllers that more care should be taken in the strategic location of work stations to minimize the effects of noise and distraction. For example, arranging the work stations back-to-back would create a physical barrier to noise and would reduce the opportunity for extraneous side chatter between controllers. CATCA officials strongly endorse such a back-to-back arrangement. However, it is recognized that there are many factors affecting work station layout and any configuration is at best a compromise in an ACC. Since a reconfiguration of current work station layouts would be highly disruptive, any potential benefits would have to be substantial to warrant such change.

The work stations of an ACC are designed with significant inherent flexibility; although highly specialized, the supporting infrastructure for one sector's work station can be combined with another or transferred to another work station. (A Data Systems Coordinator (DSC) is responsible for effecting the necessary transfers of frequencies, data lines, information displays etc.) Few complaints were received with respect to the ability to relocate work from one work station to another. However, several controllers and supervisors observed on the lack of spare equipment to accommodate breakdowns or system expansion.

There was also some feedback with respect to work station design in the centres. As more information must be readily available and/or displayed to controllers, space availability in work station layout is a prime concern. For example, finding an appropriate location to display Gander Automated Message Processing System (GAMPS) information at Gander is current cause for concern. As the manager of the ATS Research and Experimentation Centre of Transport Canada wrote:[4]

> "Modern technology is allowing us access to an increasing amount of information. There are also many more ways of presenting this information to a controller. We have reached the stage where we cannot make the workstation any more complex or more cluttered with switches, instruments, status and warning lights and aural alarms. Transport Canada's Human Factors Team is researching ways to present information in the most suitable form and to apply their work to the design of the next generation of air traffic controller's workstations."

4.2.3 Indicator Modules

Indicators modules (IMs) are the controllers' radar scopes. The current IMs were introduced in 1978 and are standard in every ACC in Canada. Being the focal point for any radar sector, they are a prerequisite in opening a new sector.

Increased traffic demands over the last several years, have necessitated reorganization of the sectors to accommodate the traffic; consequently, IMs are now in short supply. The Special Investigators were told that being of older design, procurement of additional IMs was unlikely. Thus, future expansion of the number of sectors or replacement of unserviceable units will be seriously hampered until new equipment associated with RAMP starts to come on-line in 1990. Although not yet critical, IM availability may well limit the ATS system's ability to cope with increased traffic in the short-term. All four ACCs visited during this study indicated a shortage of between one and four IMs for any possible near-term expansion. In addition, one controller noted that several IMs were now showing burn wear on the phosphorous face. Any delays in RAMP implementation could lead to serious system degradation as IMs begin to fail. Indeed, redeployment of serviceable IMs to other units will undoubtedly be required as RAMP radar displays are introduced.

4.3 COMMUNICATIONS

4.3.1 General

The provision of ATC services is totally dependent upon a reliable communications system, comprising radios, telephones, and dedicated inter-controller communications lines or hotlines. Very high frequency (VHF) radios are generally used for Direct Controller/Pilot Communication (DCPC); the military tends to use ultra high frequency (UHF) radios, and high frequency (HF) radios are required for long-range communications, such as over the North Atlantic. Dedicated telephone circuits permit direct communication between ATC units both inside and outside Canada. Quick access telephone circuits or hotlines permit immediate access between controllers within an ATS unit; these are necessary for coordinating information between sectors or between towers and terminal control units.

In order to extend DCPC, a network of unmanned radio transceivers linked directly to the Centres by landlines has been strategically located throughout much of Canada. Operating on dedicated frequencies, these PeripherAL (PAL) stations extend the area over which DCPC is available and thereby facilitate more efficient air traffic control.

The file review revealed several significant problems with respect to "communications" in the sense of information transfer. Because few of these problems were generated by equipment failures, they are discussed in Chapter 10, Information Transfer. While only four occurrences attributed "radios" as a contributing factor, the field survey phase of this Special Investigation did reveal other related problems warranting attention. These include lack of DCPC on the North Atlantic, the requirement for additional telephones and frequencies in ATC units, and significant complaints concerning the adequacy of existing headsets.

4.3.2 DCPC On The North Atlantic

The continuing inability of oceanic air traffic controllers to directly communicate with aircraft overflying the Atlantic is a fundamental safety deficiency. The technology of today's modern air transport aircraft permits extremely precise navigational accuracy, and technology will permit crystal-clear communications with astronauts in space. However, because Gander Oceanic Control does not have line-of-sight communications with the aircraft, VHF and UHF radios and PAL stations used in domestic airspace cannot be used. Therefore, controllers must rely upon communications on the HF band. While HF transmitters can achieve the necessary range to contact aircraft in mid Atlantic, clarity in voice communications is lost. This mode of communication, with its inherent technical difficulties, necessitates the use of specialist radio operators who must relay messages between controllers and pilots and vice versa, introducing another set of problems to the information transfer process, as described in Chapter 10.

HF radio equipment is also extremely sensitive to atmospheric conditions. For example on 14 August 1989, the Civil Aviation Daily Occurrence Reporting System (CADORS) reported "Gander FSS lost all HF communications due to atmospherics. Prestwick Control advised to add five minutes to all longitudinal separations."

Today's communications problems on the North Atlantic are not so much a problem of inadequate equipment, as of outmoded technology. Whereas HF radios were undoubtedly satisfactory in the 1960s, transoceanic traffic has reached a level where the inherent delays in the HF communications process are unsatisfactory; 16 minutes is considered to be normal, but it can take up to 30 minutes to relay a simple message.

An example of problems precipitated by delays in an HF communications system follows:

> On 28 April 1988, a Boeing 747 and a DC-10 westbound over the North Atlantic at FL350 were on converging tracks. Gander ACC recognized the conflict and attempted to change the altitude of the Boeing 747 without initial success. Attempts were then made to change the altitude of the DC-10. A loss of separation did occur when two clearances, either one of which would have resolved the traffic confliction, were delivered by two different communications agencies in a manner such that both aircraft climbed at approximately the same time to FL 370. Inherent system delays in HF communications were cited as contributing factors by the Fact Finding Board.

With delays in processing position reports over mandatory reporting points, problems arise in integrating transoceanic traffic into the even busier domestic traffic. When signal coverage is poor, controllers must increase the longitudinal spacing between aircraft to compensate for the delays in communication. While not inherently unsafe, the consequent backlog of traffic can create added operating pressures right back to the cockpits of the delayed aircraft.

In discussing equipment problems, controllers interviewed at Gander were virtually unanimous in recommending an early resolution of the DCPC problem. As one controller stated:

> "HF communications over the North Atlantic are totally unacceptable. With the existing state of the art and existing world communications networks, the staff cannot understand why the international agencies such as ICAO and the airlines of the World are not pressuring to have a communications network where aircraft and ATC facilities can have DCPC."

The irony of this situation is illustrated by an anecdote told by a supervisor in the Gander IFSS: apparently, a British Airways captain who, frustrated by the congestion on HF, finally passed his position report on the "skyphone", a satellite-based commercial telephone system that was available to first class and business travellers and was being tested on his aircraft. (These calls cost U.S. $9.50 per minute, hardly a large sum given the importance of the information.)

On 08 July 1987, an L1011 passed beneath the rear fuselage of a Boeing 747 with less than 100 feet vertical separation at FL310 with both aircraft westbound over the North Atlantic. While this occurrence was precipitated by a gross navigational error by the L1011, it could have been averted had ATC queried an error in the crew's estimated time of arrival over the next reporting point. Consequently the CASB recommended that:

> The Department of Transport modify Air Traffic Control procedures to ensure that any discrepancies of five minutes or more between pilot and ATC estimates on the North Atlantic be challenged by the controller at once to verify the estimate; and
>
> (CASB 88-03)
>
> The Department of Transport take immediate steps to provide more timely and reliable controller/pilot communications in the Gander oceanic control area.
>
> (CASB 89-06)

Transport Canada has adopted CASB Recommendation 88-03 for Canadian controlled airspace. Further, Transport Canada has advised other North Atlantic provider states of this recommendation and has recommended similar action to the North Atlantic Special Planning Group. At the time of writing this report, no reply to CASB recommendation 89-06 had been received.

With today's capabilities of satellite-based communication systems, Canada, the United States, Portugal, and the United Kingdom (the providers of the transoceanic traffic service) and the international users must find a more effective alternative to HF radio communications over the North Atlantic, such as to permit DCPC either by voice or data link.

4.3.3 Frequency And Telephone Availability

Feedback was received at all four of the ACCs visited, expressing dissatisfaction with VHF frequency availability, in particular with respect to the shortage of backup frequencies. Isolated incidents of "splashing" (where there is spill-over from one frequency to another) were noted. Further, while the continuing addition of PAL frequencies is facilitating DCPC throughout much of Canada, controllers foresee continued requirements for more PAL stations.

When problems are encountered on a particular radio frequency, some controllers complain of inadequate backup frequencies. At Toronto, for example, one arrival controller reported that 125.4 megahertz (MHz) was unreliable, resulting in initial contact on this frequency often being clipped. Transport Canada officials believe that this problem has already been satisfactorily resolved.

Notwithstanding the foregoing comments on frequency availability, no clear trend emerged from the file review or field survey - other than the need for continuing efforts to increase availability and reliability. Many of the current congestion problems experienced on oceanic HF frequencies shared by several agencies could also possibly be alleviated through the provision of additional frequencies.

Some of the existing telephone lines are also reportedly near saturation making it extremely difficult for timely coordination of information. For example, telephone communication between Gander, Moncton, Montreal ACCs, and Reykjavik, Iceland is by one dedicated telephone line; with today's traffic level, there are too many controllers apparently trying to coordinate information on this single line. As with frequency availability, controllers stated that "more" would always be appreciated.

In the following occurrence, a heavy, complex workload may have been aggravated by busy communications systems:

> On 08 October 1988, a loss of separation occurred between a Boeing 747 and DC-10 at Flight Level 330, 200 miles northeast of Kuujjuaq. Both aircraft were transatlantic westbound flights. While the Fact Finding Board determined that controller errors caused

> the loss of separation, during the hour preceding the occurrence, telephone lines #653, #654 and the internal lines between Ungava-Chibougamau, and Ungava-Baie James, were being utilized 2,075 seconds out of 3,600 in the hour, (a utilization rate of 57.6 per cent) and that the radio frequencies 133.2 and 134.55 were being utilized during 2,671 seconds out of the 3,600 seconds in the hour, (a utilization rate of 74.2 per cent).

Recent occurrences at LBPIA have demonstrated deficiencies with respect to the hotline system in the Toronto Centre. Subsequent to a loss of separation occurrence on 06 July 1988, the CASB concluded "The controllers hotlines were improperly labelled and transmitted on all terminal positions." And, subsequent to a loss of separation on 14 July 1988, the CASB report concluded that "The hotline system at Toronto Centre is ineffective for communications within the terminal during peak hours and therefore is seldom used at these times." Transport Canada officials too were concerned about the adequacy of the hotline system and conducted a local evaluation of the system, which led to the initiation of remedial action. On 05 January 1989, the CASB issued four recommendations to improve ATC services at LBPIA; one of them recommended that:

> The Department of Transport modify the dedicated hotline system at Toronto to guarantee direct addressing between specific positions in the Tower and Terminal Specialty such that incoming calls are heard only at the required positions.
>
> (CASB 88-16)

It is understood that Transport Canada has already effected all the necessary changes to the system.

4.3.4 Head-sets

During the field survey, head-sets were widely reported to be a problem. On the surface, some of the comments indicate that the head-sets are merely an irritant. However, when examined more closely, controllers' dissatisfaction with the head-sets is cause for safety concern.

Controllers are reportedly missing readbacks due to poor head-sets. Some controllers reported that, when using a head-set, one hand must be kept free to press the head-set closer to the ear in order to hear; this leaves only one hand free for telephone coordination and strip writing.

The controllers require a head-set which is both robust enough to stand up to continuous use and comfortable enough to be worn during a complete shift. The lightweight version provided to the controllers requires a free hand to be able to hear; consequently, many controllers prefer to use the audio speakers. However, they must still use the microphone of their head-sets for transmitting; hence the equipment gets literally "bent out of shape". At Toronto, controllers reported that over 200 head-sets have now been set aside for repair. One controller suggested that controllers be allowed to buy their own head-sets and that they be given an allowance to maintain them.

The difficulties in finding a head-set that will be acceptable to all users are recognized. Worn over long periods of time, even the most comfortable of gear will become a source of annoyance. In an effort to offer as much flexibility as possible, Transport Canada now offers controllers a choice of three modern technology head-sets. The performance of these head-sets and the reliability is being closely monitored by Transport Canada.

Clearly, the professional discipline of wearing a comfortable reliable head-set is conducive to more safe operating practices. Resolution of controllers' concerns about their head-sets is required if the accepted norms of professional discipline and safety are to be maintained on a day-to-day basis.

4.4 SURVEILLANCE SYSTEMS

4.4.1 General

The introduction of the Joint Enroute Terminal System (JETS) radar into the new ACCs provided a significant enhancement in equipment capabilities for IFR controllers. Secondary surveillance radar signals were digitized which allowed the display of not only the radar target but a co-located block of information containing flight data such as flight identification, a designator weight category in order to effect wake turbulence separation, and speed and altitude information which are automatically and continuously updated. This reduces the need for radio transmissions for altitude checks and facilitates continuous positive radar identification of flights.

Significantly, the file review showed that radar deficiencies were considered to be contributory in only two of the occurrences analysed during this Special Investigation. However, it is believed that radar deficiencies have contributed to more occurrences than the two indicated. For example:

> On 02 June 1987, a Boeing 737 and a USAF C5A Galaxy were at FL330 following their respective IFR plans over the interior of British Columbia. The flight crew of the B737 observed the C5A approaching from the left and took evasive action by altering course to the left and passing behind the C5A. The CASB determined that ATC did not adhere to standard separation procedures, thus allowing a risk of collision to develop between the two aircraft.

This occurrence was initiated in part due to the unreliable performance of the Kamloops radar. At the time of the occurrence, this radar was not displaying either aircraft as a target, and the controllers had not initiated non-radar traffic separation. (It is understood that many of the significant shortcomings in the current generation of equipment will be eventually eliminated with the introduction of RAMP.)

4.4.2 Radar Quality

Although the quality of service rendered by JETS is generally high and controllers are generally satisfied with the equipment, many controllers reported holes in the radar coverage. One controller reported that holes in the London area are "getting worse", holes which were at one time limited to FL240 and above lately have been occurring down to FL180. However, controllers seem to learn where these holes in the coverage occur and adapt to them.

Radar targets passing through these areas of weak radar coverage can decorrelate, meaning that valuable target information concerning speed and altitude attached to the digitized symbol on the controller's display disappears. Although some controllers mentioned decorrelation as a problem, no occurrences were found where the situation was specifically attributed to a possible decorrelation of the radar data.

Unreliable or unsatisfactory radar performance can also adversely affect tower operations. Following is an example of such a situation between an IFR and a VFR aircraft at Montreal:

> On 10 May 1989, a Cessna 500 and a Piper PA-31 were side by side on approach at three miles on final for the same runway, with each pilot ignoring the presence of the other aircraft. While a lack of controller planning and coordination was cited by the Fact Finding Board as the principal cause, loss of reliability of the Tower radar system was cited as being contributory. Specifically, false

radar returns and a number of false targets close to the real target and a breaking up of coverage between five and seven miles from the antenna were occurring.

Near the perimeters of the signal coverage and at lower altitudes, there are areas that sometimes lack adequate signal coverage. Sometimes this becomes a problem for controllers where two (or more) radar systems overlap. Almost all radar information used by the instrument radar controller is derived from aircraft transponders. Because signal effectiveness depends on transponder equipment on board the aircraft, controllers will sometimes lose radar information on a flight as it enters an area of unreliable signal coverage before entering the range of the adjacent radar antenna. This loss of radar information in a busy sector has lead to at least one incident.

Relief from this problem is foreseen with the introduction of RAMP which has a feature known as "mosaicing." With mosaicing, signals from different radar sites are compared and integrated, providing the controller with the strongest return for control purposes. Radar mosaicing is expected to eliminate to a large degree many of the current gaps reported in the radar coverage. At the present, time radar mosaicing is in use in British Columbia, integrating the radar data of the Kamloops and Vancouver radar antennae, and in Ontario integrating the signals of the Caledon and Toronto radar antennae.

The domestic radar sectors at Gander depend upon three separate radar sources. Controllers must switch from one radar source to another in order to provide a particular aircraft with continuing radar coverage. Thus, aircraft in one area operating under radar separation criteria are not receiving continuous radar monitoring when the controller switches to the second or third radar source. Apparently, this problem has been previously identified by Transport Canada officials and clarification is being sought.

With the introduction of the North Warning System by the Department of National Defence, there has been a significant increase in signal availability for integration into the domestic ATC system. For example, radar data from Saglek, Labrador and Brevoort Island, Northwest Territories are now available to controllers in the Montreal ACC, thus facilitating the transition from transpolar and transoceanic flights to domestic airspace in that FIR. At Gander, controllers have suggested that the radar information from the Goose Bay and Cartwright radar sources in Labrador should be made available to the Gander ACC to facilitate the transition to and from the Oceanic Control Area in the Gander ACC. (The North Warning System is also now facilitating expanded DCPC through its improved communications capabilities.)

4.4.3 Radar Scheduled Shutdowns

The integration of secondary source radar data from current and former military installations has significantly increased the capacity of the domestic ATC system. IFR flights in the area of these sites may now be operated at the same altitude with as little as 10 miles of horizontal separation.

Maintaining the requisite level of reliability for civil operations at these remote military sites has been reported by controllers to be a problem. Maintenance is conducted in accordance with predetermined schedules; however, during these scheduled radar outages, significant reclearing of aircraft occurs with the associated risk for confusion. It would be misleading to imply that scheduled shutdowns always cause problems; however, controllers and supervisors clearly indicated a desire to see more flexibility built into maintenance scheduling. At known trouble spots, they would like to see some means for altering maintenance schedules on short notice, depending upon the operational requirements at that time.

According to Transport Canada, the records indicate only isolated instances where conflicting Department of National Defence/Transport Canada maintenance scheduling could not be resolved through cooperation at the local level. In unusual circumstances, such cooperation has been achieved when Transport Canada approached Department of National Defence at the headquarters level for special consideration.

4.4.4 North Atlantic Surveillance

Notwithstanding the establishment of minimum navigation performance specification airspace over the North Atlantic and notwithstanding the quality of on-board navigational equipment today, gross navigational errors continue to precipitate serious losses of separation and sometimes risk of collision over the North Atlantic. Potential conflicts in the eastbound and westbound flows of up to 300 aircraft each way each day are identified through computerized flight planning; furthermore, the flows are well organized on each side of the ocean before leaving domestic radar coverage. However, outside of coastal radar coverage, the current system is extremely vulnerable to non-recognition of conflict and non-detection of serious navigational errors. This is particularly true as the westbound flow progresses through Gander's airspace, and requests for flight plan changes must be cleared of confliction manually.

As previously mentioned there is no direct controller/pilot communications (DCPC), nor is there a real-time surveillance capability over the North Atlantic (such as that provided by radar in domestic Canadian airspace). Hence, routinely Gander oceanic controllers face a board with 40 or 50 paper strips representing aircraft at various stages of progress in their sector of airspace on different tracks and at different altitudes. Collision avoidance is largely dependent upon the controller's abilities to organize these paper strips, constantly scan them, and mentally analyse the situation, based upon progress reports which may be 30 minutes to one hour old. Some of the busiest work in these sectors is done during the early hours of the morning, when human psychological and physiological response capabilities are at their lowest. Two examples of undetected loss of separation occurrences over the North Atlantic are described below:

> On 13 June 1988, a loss of separation occurred between a DC-8 and an L1011 westbound on North Atlantic track Alpha, when the DC-8 was cleared to climb to flight level 310, resulting in the DC-8 crossing the L1011 track with approximately three minutes longitudinal spacing (versus the 15 minutes required). The controller approving the altitude change for the DC-8 did not detect the conflict. A second controller assumed responsibilities for the position eight minutes after the altitude change approval, and he worked the position for approximately 55 minutes but did not detect the confliction. Finally, a third controller assumed responsibility for the sector and detected the error approximately six minutes later.
>
> On 14 November 1987 a loss of separation occurred between two Boeing 747s, both proceeding westbound on NAT track Delta, one at FL310, the other at FL330. The first aircraft was cleared to climb to FL330. For a period of approximately 40 minutes, both aircraft flew the same track at FL330 with one to two minutes of longitudinal spacing (versus the required 10-minute separation). The controller had not detected the conflict situation.

Of equal concern is the need for early detection of gross navigation errors. While on-board navigational systems have tremendous inherent redundancy, human errors in entering waypoint coordinates into the Inertial Navigation Systems (INS) have resulted in gross navigational errors. For example:

> On 08 July 1987, a westbound Lockheed L1011 passed immediately beneath a westbound Boeing 747 at FL310 with less than 100 feet vertical separation. The L1011 had deviated 80 nautical miles south of its assigned track after passing 30 degrees west. The CASB determined that the

> navigation error was the result of a data input error by the L1011 flight crew.
>
> On 09 July 1989, an eastbound L1011 deviated 120 nautical miles south of its assigned North Atlantic track at FL350 creating technical losses of separation with two other aircraft and creating a risk of collision with another two aircraft. While the CASB's investigation is ongoing, initial indications are that the L1011 flight crew had made a 2 degree error in programming the INS for the North Atlantic crossing (53°N 40°W west was inserted instead of the correct 55°N 40°W).

Without some form of real-time surveillance over the increasingly heavy and complex air traffic over the North Atlantic, such gross navigational errors will frequently go undetected. An ICAO special committee on Future Air Navigation Systems (FANS) is considering a system known as Automatic Dependent Surveillance (ADS). With ADS, aircraft will automatically transmit positional data derived from their on-board area navigation systems to ATC facilities via an air/ground data link, thereby providing controllers with the surveillance information necessary to monitor the flow of air traffic and detect any potential conflict situations. Satellite communication systems could facilitate DCPC to effect necessary changes in routing to maintain safe separation between aircraft.

Transport Canada recognizes the problem. The Canadian Airspace Review (CAR) Recommendation 6.1.1.24 recommended research and engineering development be carried out in coordination with industry and users to test and further the use of data link systems that use space and terrestrial technology for air/ground communications, navigation and surveillance (CNS) purposes. It is understood that Transport Canada is conducting related research at the present time through the Transport Development Centre. In addition, CAR Recommendation 6.1.1.25 recommended modernization of ATC systems to include the capability to process CNS data link messages. The current CAR implementation plan accepts this recommendation for implementation by 1994. Transport Canada has also accepted CAR Recommendation 2.3.2.16 and 2.3.2.17 seeking a determination of overall requirements for and the potential use of dependent surveillance in non-radar areas and to conduct the necessary research and development for dependent surveillance systems as identified by the operational requirements. Transport Canada has also accepted these recommendations for implementation in the early 1990s.

Notwithstanding Transport Canada's best efforts, significant international cooperation will be required to redress the real-time surveillance issue. While nations are cooperating through such fora as the North Atlantic Special Planning Group (NAT/SPG) and through ICAO's Special Committee on FANS, progress has been slow. Indeed, the issues have been largely known since the 1950s. It is understood that the U.S.A. and the U.S.S.R. are currently discussing possible scheduling for the necessary satellite deployments, possibly for the 1993-94 timeframe. Notwithstanding, since any improved system must be capable of accommodating both older technologies and the most modern systems deployed on aircraft, the international air carriers themselves must demonstrate their intent to participate in any new real-time surveillance systems.

Regrettably, a real-time surveillance system appears to be years from operational implementation. Yet, the operational requirement for such a system is clearly there today. Nations operating aircraft over the North Atlantic must cooperate to develop and implement a viable real-time surveillance system for the earliest possible implementation. While such a system will undoubtedly have to be satellite-based, it may incorporate radar or data link as described above. International cooperation is being achieved with respect to the implementation of satellite-based navigation systems. The need for cooperation in developing and implementing a surveillance system to provide a safety net for North Atlantic traffic is at least as great; human errors can compromise the most technologically advanced navigation systems. Indeed, in terms of priorities for implementing satellite-based systems, it would appear from a safety point of view that, first DCPC must be established, perhaps coincident with an Automatic Dependent Surveillance System - before a satellite-based navigation system is implemented.

4.5 AUTOMATED SYSTEMS

4.5.1 General

With the increasing traffic of the late sixties, Canada recognized the need to automate information processing systems to reduce the enormous paper-handling problem in the ACCs. Up until that time, individual flight plans were filed for each flight, and flight progress strips were copied by hand at each controller's work station. To reduce this logistical tangle, the first flight processing computers were introduced.

The Joint Enroute Terminal System (JETS) discussed above now permits controllers to "hand off" or transfer aircraft information between controllers in the same ACC without verbal coordination. Telephones, radio frequencies, and hotlines within the ACCs are controlled by an Integrated Communications Control

System (ICCS), a large automated switching device. The National Flight Data Processing System (NFDPS) was introduced in the ACCs with co-located terminal control units; this equipment integrates flight data from computer-stored flight planning data and from individual flight plans and it automatically generates flight progress strips on printers at the appropriate sectors for the use of the controllers.

Special purpose information displays were introduced at each controller's work station. The Operational Informational Display System (OIDS) provides controllers with both real-time data such as wind direction and speed, temperature, barometric pressure and visibility for all major airports and such static information as weather sequences, Notices to Airmen (NOTAMS) and other related aeronautical data, such as runway condition reports. This information is complemented by a Visual Information Presentation (VIP), a slide/projector system providing the controller with detailed text and graphic information on specific areas of the sector responsibility; e.g., local IFR and emergency procedures, VFR flying areas, etc.

4.5.2 Joint Enroute Terminal System

While JETS gave controllers a significant increase in capability and reduced workload considerably, JETS software does not have a conflict alerting capability. At the time that this function was defined as a necessary item in radar data processing, it was decided, for reasons of cost-effectiveness, to concentrate on incorporating it in the RAMP RDPS (Radar Data Processing System) which is replacing the JETS central processing subsystem. If RAMP is delivered on schedule, RDPS should become available in the ACCs sometime during 1990.

At present, during busy or complex traffic situations, controllers frequently find themselves in a situation requiring continuous radar monitoring. Distraction or lapses in vigilance can result in a risk of collision situation being overlooked, without any form of "safety net." The following examples are indicative of the hazards of such situations:

> On 03 November 1987, a risk of collision occurred between a DC-10 and a Boeing 737 inbound to Toronto while flying in accordance with IFR under VMC. Neither flight crew observed the other until the aircraft were dangerously close to each other. The CASB determined that the controller responsible for separation of the two aircraft placed himself in a situation that required continuous radar monitoring of the two aircraft to ensure separation. His attention was

> diverted from radar monitoring because of other controller-related duties, and he did not provide adequate separation of the two aircraft. The situation was exacerbated by the normal disappearance from the radar screen of the JETS Tag Information on one of the aircraft as it overflew the radar antenna.

Even in conditions of light traffic, a conflict prediction capability could prevent the development of potential collision situation. For example:

> On 27 July 1989 at LBPIA, the Arrival controller mistakenly descended a DC-9 on approach during light traffic conditions from 7,000 to 6,000 feet bringing it within 100 feet vertically with no horizontal separation of a BA31 Jetstream also on approach at 6,000 feet. Without a conflict alerting capability, this controller's temporary lapse in judgement and vigilance resulted in a near collision situation.

JETS also lacks the capability to electronically "hand off" aircraft from one centre to another, either in Canada or to adjacent U.S. centres. It is understood that Canadian Automated Air Traffic System (CAATS) will have the capability to automatically distribute flight data between units, thus reducing the chance of error. However, the initial contract for CAATS was only awarded in November 1989; the flight data processing systems and displays of CAATS are not expected to be fully implemented much before the end of 1996. Therefore, in the meantime, communications requirements between controllers will remain high to effect the required transfer of control of aircraft. Communications and coordination problems are discussed further in Chapter 10, Information Transfer.

4.5.3 Northern Airspace Control System (NACS)

The NACS is an automated system used for non-radar control in Canada's far North by the Montreal, Winnipeg, and Edmonton ACCs. Based upon pilot position reports, flight-planned tracks, and speed and known upper level winds, this system computes projected aircraft estimates along the flight-planned track and gives the controller a coloured visual display. Although the system is not updated in real-time as with a radar display, this system does provide the controller with a visual image, not readily apparent from a board full of paper progress strips. This allows for a more rapid assessment of potential conflicts when a pilot requests either an altitude or a route change. Furthermore, the algorithm used in the NACS does have a conflict prediction capability.

Controllers in the North subunit in Montreal were highly enthusiastic about this new equipment. Apparently, on 07 June 1989, this section handled 115 aircraft in four hours without problems; previously such volume would have resulted in chaos. Although updating the system is labour intensive, the visual display and conflict prediction capabilities are particularly beneficial during busy traffic periods. Furthermore, the system is easy to use, with only two days of training time being required for qualified controllers to become proficient.

4.5.4 Gander Automated Air Traffic System (GAATS)

The GAATS produces flight data strips for oceanic controllers and calculates flight estimates for particular degrees of longitude, taking into account the winds aloft. The computer algorithm is analogous to that used in the NACS and does have a capability for predicting air traffic conflicts for the eastbound flow of traffic. While efforts are ongoing to add a universal conflict prediction capability (perhaps by late 1990), Gander controllers were quick to point out this shortcoming in the system. Furthermore, GAATS does not provide controllers with a visual display, such as that available to the northern controllers using the NACS. While the GAATS unquestionably is a significant step forward for the Gander controllers, because of its current shortcomings, over-reliance on the system can set up loss of separation occurrences. For example:

> On 3 August 1987, a Boeing 727 and a L1011 were operating on converging tracks at FL310 and were estimated to have 17 minutes separation at the crossover point. The required 15 minutes separation was reduced to four minutes spacing. The estimates being produced by the GAATS computer were not accurately reflecting the actual times of the aircraft's progress. The oceanic controller was aware of the inaccurate GAATS times. From 30 degrees west the Boeing 727 actual progress and estimates were significantly later than the GAATS estimates. Conversely, the L1011 progress was slightly earlier than the GAATS estimates, thus reducing the expected separation at the crossover point to four minutes. The controller had not updated the computer-generated estimates based upon the actual position reports.

Pending the implementation of DCPC and a real-time surveillance system over the North Atlantic, Gander Oceanic controllers require an increased level of automated support - especially given today's increasing transoceanic traffic levels. It is believed that the algorithms of the GAATS must be further developed and visual displays provided to give Oceanic controllers at Gander a sharper appreciation of the traffic situation. The following occurrence demonstrates the need for some form of visual display:

> On 07 August 1989, a DC-10 and a B727 were both westbound over the North Atlantic at FL280 on tracks that were not laterally separated. According to the Fact Finding Board, both the Reykjavik and Gander controllers failed to detect that the assigned tracks would converge to less than 60 miles laterally between 40W and 50W. The Gander controller had not questioned the type of separation being applied by the Reykjavik controller.

Nowhere is the disparity in technological capabilities between airborne and ground-based systems greater than for oceanic control. As discussed earlier in this chapter, aircraft with the most modern navigational systems and cockpit presentations are operating in an ATC environment relying upon an unreliable communication system, the management of hundreds of paper flight data strips and the manual handling of thousands of telex messages daily.

4.5.5 Systems Approach

While the introduction of such programs as JETS, RAMP, and the CAATS are major projects requiring the ultimate in systems integration, there is some evidence that the systems approach being taken to equipment design has shortcomings. Such equipment as the NACS, GAATS, and GAMPS, are commendable initiatives in themselves, particularly considering their relatively low cost versus the dividend in simplifying controller workload. However, some of these equipments and technologies have potentially broader application and have significant growth potential if better integrated into the overall ATS system. For example, it is believed that, with further system development, GAATS and GAMPS could be integrated to update the GAATS database for better conflict prediction. It is understood that such a development will take at least another five years. Furthermore, it is understood that many of the items in the current two-year backlog of Operational Condition Reports and Equipment Change Proposals have the potential for simplifying or reducing controller workload.

The latest generation of air transport aircraft have remarkably accurate navigational systems. The on-board computational capabilities are such as to permit extremely accurate track, speed, and altitude control, both en route and during climb and descent. This operational capability unfortunately is not being fully exploited by current ATC systems and procedures. For example, only slowly are ATC procedures evolving to accommodate the current capabilities of Area Navigation (RNAV). Task Group 2.3.1 of the Canadian Airspace Review did recommend that high-level airspace procedures and criteria evolve to unrestricted operations based on area navigation techniques and that low-level airspace procedures and criteria evolve to permit random route operations based on area navigation techniques. Transport Canada has accepted both of these recommendations for implementation, and RNAV routes and related separation criteria have been developed in consultation with industry. However, further benefits to be gained from on-board automated aircraft systems will only be achieved through advanced automation of the ground-based systems. This is not expected to occur until Phase II of the Canadian Automated Air Traffic System (CAATS).

In a recent study on the impact of advanced technology on cockpit operations, Earl L. Wiener concluded:

> "It is regrettable that from the beginning, aircraft and ground based ATC systems were designed, developed, and manufactured almost as if they were unrelated and independent enterprises. Even the current developments in ATC and in flight guidance systems reflect this proclivity. The proper utilisation of aircraft and airspace will only be achieved when aircraft designers and those who design and operate ground based ATC work in closer harmony. It seems strange that in 1989 it is still necessary to say that."[2]

4.6 THE FUTURE

Development is well underway for the complete automation of all flight data handling in Canada, hopefully following the systems approach suggested by Wiener. The Canadian Automated Air Traffic System (CAATS) will incorporate conflict alerting, minimum safe altitude warning for non-radar coverage areas, increased accuracy of flight progress, and the complete interconnection of ACCs, Civil and Military ATC Units and FSSs. Airline dispatch offices and other selected users will have access to the system through remote terminals. This system will be interconnected with the radar processing system which will produce a totally integrated automated ATS system for civil and military users in Canada. It will also be connected to ATS systems in adjoining countries. The Minister of Transport announced the Government's decision to award the initial contract for CAATS (for approximately $380 million to Hughes Aircraft of Canada) on 23 November 1989.

The RAMP will upgrade the present radar systems with new solid-state, primary and secondary surveillance radar systems. The new Primary Surveillance Radar will employ advanced signal processing, permitting improved target and weather detection. The Secondary Surveillance Radar System will employ monopulse techniques for greater positional accuracy and will be upgradable to SSR Mode S operation (which is compatible with U.S. approved equipment for airborne collision avoidance systems.) The first RAMP radars are scheduled for implementation in 1990.

In the U.S.A., the FAA has adopted strong requirements for the implementation of a Traffic Alert and Collision Avoidance System (TCAS). FAA legislation will require the fitment of TCAS II equipment on commercial aircraft entering domestic U.S. airspace with more than 30 seats after 31 December 1993. At a 1988 conference on TCAS hosted by Transport Canada in Ottawa, Air Canada indicated plans to fit their aircraft with TCAS equipment, presumably to enable their operation in American airspace. Given the frequency and severity of loss of separation occurrences involving transport-category aircraft on IFR operations in Canada, some form of airborne collision avoidance system is required for Canadian flight operations in order to provide flight crews for these aircraft with the necessary information to avoid collisions when all other forms of separation fail. CAR Recommendation 5.2.1.6 recommended that Transport Canada, in consultation with the users, explore the relevant benefits of an airborne collision avoidance system and that full consideration be given to the final decision of the FAA. Transport Canada currently is having a risk analysis study completed and intends to conduct a benefit/cost analysis in the future.

The Canadian Airspace Systems Plan (as discussed further in Chapter 11, Management) provides a coherent plan for upgrading all ATC equipment. With respect to the ATS system, the CASP emphasizes the following system and equipment aspects:

> "-extended use of automation in conflict prediction and resolution to permit increased control capacity and efficiency.
>
> -the use of common controller work stations with common modular hardware, and software based on the use of a high-level language.
>
> -air-ground data link for automatic two-way transfer of information (clearances, weather etc.)
>
> The systems and equipment used in ATC facilities will be standardized, with most hardware and software elements being identical. The computer systems and controller workstations for the ACCs and TCUs will be the same except for the

capacity of the computers. Appropriate communications control systems to support the ATC operation will be provided. To the extent practicable, towers will use the same equipment.

The heart of Canada's ATC system modernization is the Canadian Automated Air Traffic System (CAATS) project. This project will provide extensive automation leading to the on-line acquisition, processing, display, and transfer of flight data. The project will also provide the common controller workstations.

A distributed processing approach to data management will continue to be the basis of the ATC system design. Central processors, such as the flight data processing system and the aeronautical information processing system, will support large data bases accessible by all ATC facilities and carry out major processing functions.

The common controller workstations will provide a new environment in which air traffic controllers will be able to function more efficiently and effectively. Each CCWS will contain redundant processing and the digital displays will be functionally interchangeable. Tactical data (plan view traffic situation), will be displayed, as well as supplementary aviation information. Additionally, strategic displays will replace the current flight strips for indication of flight plan data. Planning and probing displays will be used for indication of conflict-free, fuel efficient flight profiles.

The CCWS processors will be designed to enable a degree of autonomous operation and will select required surveillance, flight data and weather information from distribution networks and process data necessary for the particular controller position. If a central processor fails, the CCWS processors will be able to provide essential services by utilizing information available on distribution networks, combined with that maintained in local data bases.

The distributed processing and network techniques inherently provide high availability and protection from total system failure. This enables increased operational flexibility since the number of ACC controller operating positions can be reconfigured to meet changing demand based on day-to-day or hour-to-hour workload considerations. With daily variations in traffic demand controller workstations and associated communications can be configured into appropriately sized operating sectors with optimum staffing."[5]

If the Canadian Airspace Systems Plan can be implemented in full without slippage, an appropriate margin of safety for equipment-related problems should be maintained in Canadian Domestic Airspace. However, should the major programs of the CASP be delayed, for whatever reasons, it is doubtful that the requisite level of safety can be maintained by applying more controllers and ever more complex procedures to the expected increases in air traffic.

Even with the timely implementation of the major CASP projects, currently deployed systems will require continuing attention. Incremental improvements to the effectiveness and safety of the current ATC system can still be achieved, given appropriate "care and feeding." The potential for attaining these improvements at marginal cost should not be overlooked in the rush to implement the high technology solutions.

4.7 OBSERVATIONS

1. Equipment was found to be contributory to ATS operating irregularities in fewer than 10 per cent of the occurrences analysed.

2. The control towers at Toronto and Vancouver are overcrowded, and the information displays are poorly laid out from an ergonomic standpoint.

3. The current arrangement of ACC workstations results in excessive noise and distraction at adjacent work stations - particularly during high activity levels.

4. There is a shortage of IMs which could become critical if there is any slippage in the RAMP program, unforeseen IM unserviceabilities, or non-forecast demand for opening additional sectors.

5. Without Direct Controller/Pilot Communication and a real-time surveillance capability on the North Atlantic, the effectiveness of ATC over the ocean is compromised. Given increasing traffic levels, the "safety net" needs to be strengthened.

6. There is a reported shortage of spare frequencies both in the VHF and in the HF bands, and a shortage of dedicated telephone lines.

7. Controller dissatisfaction with the comfort and reliability of their head-sets warrants continuing attention.

8. The relatively minor problems with radar quality extant today will be largely resolved with the implementation of the RAMP program.

9. Implementation of the North Warning System is making a significant increase in radar data available for ATC in the peripheral regions of Canada; a coordinated national plan will be required to ensure that radar data accessible through the NWS is optimally distributed to the ACCs that can best make use of it in the provision of ATC services.

10. Controllers would like to have more flexibility in scheduled radar maintenance shutdowns to allow for operational requirements.

11. JETS has neither a conflict alerting capability nor the ability to hand off aircraft from one centre to another electronically. Any delays in implementation of RAMP or CAATS will prolong this unsatisfactory condition.

12. The Gander Automated Air Traffic System (GAATS) does not have a westbound conflict prediction capability or a visual display system.

13. With three separate radar sources in Gander Domestic Airspace, controllers must switch manually from one source to another, thereby compromising their ability to monitor any particular aircraft's progress continuously.

14. The approach currently being taken by Transport Canada to systems integration appears to be slow to take advantage of the technological capabilities already available. There is considerable evidence that the capabilities of currently deployed systems could be enhanced in such a way as to significantly reduce controller workload.

15. The Canadian Airspace Systems Plan is a commendable plan for upgrading ATC equipment. However, any slippages in implementation of the major projects therein (such as RAMP or CAATS) will seriously undermine the ability of the ATS system to maintain the requisite levels of safety as traffic volumes continue to increase.

16. While attention is focused on implementing the major programs of the CASP, continuing attention to enhancing the capabilities of currently deployed systems will also be required.

17. At the present time, Canada has no formal plan for requiring the implementation of some form of airborne collision avoidance system on large transport-category aircraft.

18. With respect to the development and implementation of satellite-based systems, priority should first be given to enhancing direct controller/pilot communications, perhaps coincident with providing real-time surveillance in oceanic control areas through the use of automatic dependent surveillance systems, before embarking on satellite-based navigation systems.

LIST OF REFERENCES

1. Air Transport Management, July/August 1989 issue.

2. Wiener, Earl L., "Human Factors of Advanced Technology ("Glass Cockpit") Transport Aircraft", NASA Contract NCC2-377, May 1989

3. Bernier, Diane et Luc, Edith, "La qualité de la vie au travail au centre régional de contrôle aérien de Montréal, Ministère des Transports", juin 1987.

4. Paine, Trevor, G., "Information Presentation to Air Traffic Controllers - Ergonomic Considerations", International Journal of Aviation Safety, December 1984.

5. Transport Canada TP4334E, " Canadian Airspace Systems Plan", September, 1988.

CHAPTER 5

STAFFING AND WORKLOAD

5 INTRODUCTION

Air traffic controllers, supervisors, and managers system-wide all agree that, in 1989, the ATS Branch is critically short of staff. Opinions on the reasons for the shortage vary, but it seems the problem is the result of a combination of factors and events which unfolded in the early and mid-1980s.

5.1 FACTORS IN THE STAFFING SHORTAGE

5.1.1 Resource Alignment Project (RAP)

After a peak in 1980/81, the world-wide recession complicated by an earlier fuel crisis, resulted in a weakening in air traffic demand. Within a year, the IFR traffic figures flattened and VFR traffic was on a downturn. A phased implementation of modern automated equipment for ACCs (i.e., JETS) was well underway, and the more efficient equipment was already dramatically improving IFR controller productivity. Furthermore, lower than average attrition was experienced for the ab-initio controller training courses conducted in 1981/82.

In 1982, encouraged by senior bureaucrats and in response to a number of functional audits which determined that IFR controller staffing practices required thorough review to ensure an acceptable degree of efficiency and system consistency, ATS management decided to conduct a Resource Alignment Project (RAP). The RAP project team was tasked with the development of IFR controller staffing standards. Development of these standards was to serve two purposes. First, there was an immediate need to re-establish the number of staff required to provide IFR control services. Second, there was a longer term need to develop a management tool which was to be used to better describe future IFR staffing requirements. Inherent in the commissioning of RAP was an acknowledgement that the staffing justification processes in use at the time had evolved to a state that was not really representative of staffing needs.

To determine the number of IFR controllers required to service user demand, extensive data collection exercises were conducted to address what were considered the three key components of the staffing question:

1. Workload measurement: Complexity ratings (Pace Level) were established at each control operating position (taken during representative busy periods).
2. Hourly staffing requirements: Actual numbers of controllers required for each position were sampled hourly (seat counts).
3. Representative daily conditions: Annual staffing requirements were based on workload conditions and hourly staffing demands for peak days (90th percentile day traffic volume) as well as for days of regularly reduced demand (weekend staffing factors).

This study concluded that past "point-count" standards were no longer representative of need, the main reason being that productivity gains attributable to automation and an increased network of radar surveillance were not reflected in the point-count standard in use. The magnitude of the productivity gains were such that the then current allocation of operating IFR controllers was found to be approximately 150 person years (PY) in excess of that required to control traffic.

Since RAP had identified a surplus of controllers, it was decided in 1982 to halt ab-initio training until the system showed some growth. Students in the system at that time and those attending community colleges in aviation disciplines in Quebec and Ontario were permitted to continue their training.

5.1.2 First Line Supervisor

At about the same time the Resource Alignment Project was undertaken, a reorganization plan for the ACCs was approved. This plan incorporated a critical decision regarding first-line supervisors in the ACCs. For several years, supervisors had tended increasingly to fulfil non-control duties for ever larger shares of their work day with the inevitable result that in 1982 many were unable to assume control responsibilities at all. However, with the introduction of shift managers into the ACC as part of the reorganization, many of the duties previously performed by the supervisor were transferred to this higher level manager. It was decided to re-integrate supervisors into the operational controller complement. Thus, relieved of their load of administrative functions, supervisors were freed to take on a team-leader role within the subunit. This new role included active control of air traffic.

Subsequently, about 130 supervisors were required to revalidate their ATC licences. As a result, many control positions (typically those with short-term or sporadic demand during a given shift) could be staffed by supervisors, resulting in a reduced requirement for full-time (i.e., required for an entire shift) controllers. Since the aggregate effect over the next several years was expected to result in further efficiencies from the then current allocation of controllers, it was decided to totally incorporate supervisors across the system into the staffing figures. Thus, where RAP had resulted in a decrease in the controller population at an ACC from, for example 100 to 80, plus 20 supervisors, the decision to incorporate supervisors in the staffing levels typically resulted in the establishment of a controller population at about 60, since 20 supervisors were available to perform control duties. As a result, what initially was identified as a surplus of 150 controllers through RAP, eventually resulted in a real loss of about 280 PYs to the system.

The immediate consequence of the new staffing figures was not to lay off or release employees. Reductions to the new figure were to be carried out through a combination of natural attrition, transfers of some employees to regions were attrition was having the greatest impact, and a complete cessation in training.

5.1.3 A-Base and ATS Staffing Strategy

In 1982, Ministers of the Treasury Board expressed concern that Transport Canada's Human Resources Requirements Plan did not define adequately the justification for an increase in resource levels. Consequently, in November 1982, the then Air Administrator established an A-Base Review Task Force with the mandate of reviewing the resource requirements for the Canadian Air Transportation Administration for Fiscal Year 1983/84. The objective of the A-Base Review Team was to identify the most efficient and economical level of resources that would enable the Air Adminstration to meet its mandate according to the Aeronautics Act. Included was a review of the resources required for the provision of ATC services.

The A-Base Review Team evaluated the effectiveness of the use of allocated resources in terms of their contribution to flight safety, to the level of service, to the efficiency of the operation, and to the overall capability of the unit under review. Each review took place in four phases which included critical examination and challenge by the unit under review. An essential ingredient of the process was the active participation by all levels of management to facilitate accurate assessment of resource requirements, identification of reasons for differences between current and proposed resource levels, and a mutual challenge process. In the case of ATC units, the A-Base Review Team also compared appropriate sites in the United States to Canadian sites to assess resource requirements. At the conclusion of their review, the Review Team drew up final recommendations for resource allocations.

The A-Base study identified additional controller surplus, particularly in airport control towers due, in large part, to the dramatic slow down in VFR activity levels. The resulting manpower strategy for ATS attempted to balance surplus to shortage, and novice controllers, particularly from Quebec, were required to transfer to areas of greater need, generally in the Pacific, Western, and Central Regions.

While recognizing a surplus in 1984, on the one hand, the ATS manpower strategy plan forecast a requirement for growth in 1988 on the other. Due to the two years lead-time required to train controllers, ATS management forecasted a need to restart ab-initio training in 1985/86.

5.1.4 Other Government Policy

There was a sharp increase in air traffic in 1984, and it became clear to the ATS Branch that additional manpower resources would be needed. The ATS Branch Multi-Year Operational Plan (MYOP) published in December 1984 acknowledged the developing problem and proposed increases in staffing figures established in the A-Base Review and a modification to the complete integration of supervisors into the staffing figures. To quote:

> "The AI (air traffic controller) population will be decreasing at an average rate of 75 per year for the next five years.
>
> To appreciate the impact of the above concerns on the Branch's ability to meet its mandate, one must understand clearly the staffing processes and the associated career path of its employees and the domino effect it has on all levels of the service.
>
> However, unless it is recognized that resources above and beyond the A-Base levels are necessary to provide the manpower output needed to meet the workload demand identified in the A-Base process, the Branch will

> eventually be faced with reverting to extensive overtime and/or reducing services.
>
> The ACC reorganization required that all the first line supervisors in the ACC's (136) be operationally current and occupy an operational position as identified in A-Base. e.g. The number of operational positions in the Montreal ACC is 84, twenty of which are occupied by first line supervisors. This 100% integration is proving to be unrealistic in a number of locations. 80% integration would necessitate an additional 27 P.Y.s nationally."

Unfortunately for ATS, the warning outlined in the 1984 MYOP was not heeded by Transport Canada's senior management.

The situation was further complicated by political events. On 04 September 1984, the government changed and immediately plans were announced to downsize the Public Service. Meanwhile, the levels of IFR and VFR traffic were increasing in response to a healthier economy.

In 1985, an overhead reduction plan was developed to respond to the downsizing policies of the government. As a result, a further 182 positions within ATS where earmarked for elimination over a subsequent six-year period, most of these being non-operational specialists in the ATS regional offices.

5.1.5 Delays to Recovery

By late 1985, as a result of substantial controller attrition, the ATS Branch obtained authority to commence recruitment with a goal to restart ab-initio training again in early 1987.

During the summer of 1986, while recruitment and selection standards were being developed, Transport Canada's Program Control Board (responsible for ensuring effective resource allocation) questioned re-initiating ATC training on an urgent basis. Time was lost as ATS management scrambled to justify once again the forecast need. In late September, planning continued.

Over the next several months, while recruitment and selection were underway, Transport Canada's Personnel Branch, unsure of the ramifications of downsizing activities and desiring to review closely the selection process with an eye to employing existing public servants who had been affected by staff cuts, retarded the process further. Though training had been originally scheduled to restart in January 1987, it was June before the first course was launched.

Meanwhile, since 1985, growth in traffic continued at an accelerating pace. Traffic counts in 1987 alone rose dramatically, averaging 10 per cent nationally and almost 15 per cent in the Toronto Region - well in excess of forecast traffic growth. In addition, the "hubbing" concept introduced by the airlines and the rapid expansion in the number of commuter carriers significantly increased demands upon the system. To maintain levels of service, additional positions were added. However, as the full impact of economic deregulation became evident, staffing levels within the ATS Branch were quickly becoming inadequate to meet the demands of the rapidly expanding traffic levels.

5.2 CURRENT STAFFING LEVELS

As of 01 December 1988, the ATS Branch had a total resource allocation of 3,326 PYs, and a total strength of 3,184 employees. The resource allocation for air traffic controllers was 1,924 PYs and the controller strength was 1,831. This system-wide shortfall is exacerbated by the fact that some units are over their allocation, resulting in shortages at other units greater than that indicated by the overall shortfall.

In ACCs, the controller establishment was 757 PYs and strength as of 01 December 1988 was 650, i.e., 87 per cent. Two ACCs were at strength, or in excess of their allocation, while the remainder were operating at 77 per cent strength. The most acute staff shortages were at Toronto, Vancouver, and Gander.

TCUs were at 86 per cent strength, with the Ottawa TCU experiencing the greatest staff shortage (approximately 20 per cent). The 14 major airport control towers were operating at 88 per cent strength. Several were at full strength, while Toronto LBPIA was significantly under strength (by approximately 35 per cent).

Adding to the problem of controller shortages is the fact that a significant portion of the controller allocation at some units is unavailable to perform controller functions. These include controllers on long-term disability, on maintenance-of-salary due to loss of their license endorsement for medical reasons, or on special assignment. Further, additional portions of the allocation are consumed by the significant numbers of personnel (nearly 100) taking advanced training at operational units. The result is that too few controllers are available to service the traffic demand.

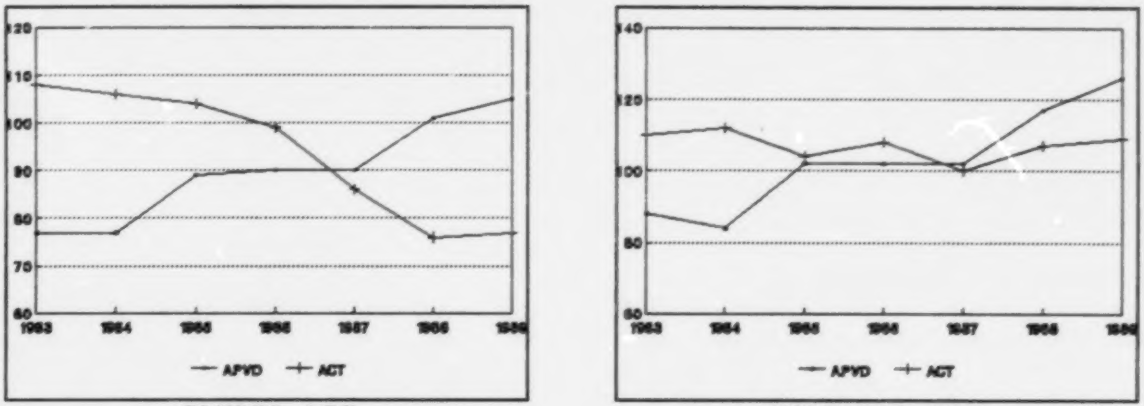
When these other factors are taken into consideration, the number of controllers available to work a sector falls significantly short of the number required. For example, staffing figures provided by the ATS Branch (effective 22 June 1989) show that at Toronto ACC, the approved staffing level for working controllers and supervisors was 184; the number of controllers and supervisors actually available for work was 129. Similarly, at Vancouver ACC, the approved staffing level was 94; the number of controllers and supervisors available was 78. At Montreal ACC and Gander ACC, the approved staffing levels were 126 and 105 respectively; the respective number of controllers and supervisors available were 109 and 77.

Table 5-1 illustrates the difference between approved staffing levels and available controllers at these four units since 1983.

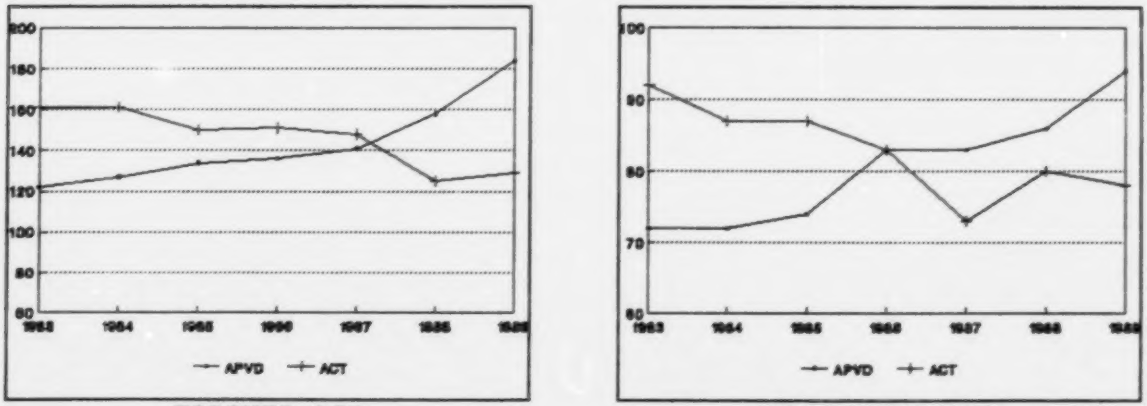
As a result of the shortfall in controller staffing levels, there has been a requirement to impose traffic restrictions and flow management at some locations. Most notably, a 70 movements per hour restriction was imposed at Toronto LBPIA in December 1988. However, there are other, less drastic flow management tools in place to assist in matching traffic flow to controller availability. For example, flow metering into certain sectors is often imposed at Vancouver to match traffic with the level of staffing within a subunit of the ACC. Furthermore, at the present time Vancouver is considering the adoption of traffic restrictions and a reservation system similar to that in place at LBPIA.

STAFFING

Table 5-1
As at 31 March Each Year



GANDER ACC MONTREAL ACC



TORONTO ACC VANCOUVER ACC

- Figures show only sector controllers and supervisors
- APVD = recognized requirement ACT - Actual number available for work
- Figures prior to 1987 for ACT have not been reduced for maintenance of salary and long-term sick leave

5.2.1 Attracting Staff to Busy ACCs

Staffing shortages at these units are made more acute by the difficulties experienced in attracting already qualified controllers from other units. In the past, attrition at ACCs was substantially overcome through voluntary transfer of controllers from the stand-alone terminal units or airport control towers. However, since the 1970s, it has been increasingly difficult to attract controllers from such sources to the busy ACCs. Several disincentives to transfer to the Toronto and Vancouver ACCs in particular were cited by Managers and controllers alike. They include: the increased work stress levels present at busy ACCs; high cost of living associated with the larger urban centres where ACCs are located; concerns over the potential failure to check out, coupled with no guarantee that the individual would be able to return to their previous unit in the event of failure; and the absence of an overall rationale for career development. Many felt that current Public Service rules and regulations governing staffing present a hindrance to effective career development and efficient staffing.

A number of incentives exist to counter the perceived disincentives to transfer to the busy ACCs. They include facility pay premiums ($6200 per annum at Toronto ACC and $4000 per annum at Vancouver and Montreal ACCs) and recently introduced provisions to ensure return rights to airport controllers who fail to check out at the ACC. Notwithstanding these incentives, attracting controllers to the ACCs continues to be a problem. The inability to attract qualified controllers to the most critically understaffed ACCs is illustrated by a 1988 system-wide call for volunteers to relocate to Toronto ACC; there were none. Similarly, in Vancouver, a recent effort to attract candidates to the East Specialty of the Vancouver ACC netted only one candidate. The end result has been a significant requirement for direct-entry IFR controllers from the ATS Training Centre with the associated problems of high training attrition (see Chapter 6, Training).

5.2.2 Recent Staffing Initiatives

By early 1988, it was obvious that the capacity of the Toronto ACC would be exceeded long before the training system could adequately respond to what was rapidly becoming a critical staff situation. As a short-term solution, the Public Service Commission and the Department of Employment and Immigration approved the hiring of about 45 experienced American controllers, with a provision to hire additional American controllers in the future should demand warrant. ATS management report that they are now also in the process of attempting to hire Canadian citizens with previous ATC experience.

In December 1988, during its investigation of an occurrence at LBPIA on 06 November 1988 in which an Airbus A310 and a Boeing 737 came within 2,000 feet horizontally and 100 feet vertically of each other, the CASB made four recommendations to the Minister of Transport; one of which recommended that the Department of Transport take immediate steps to ensure that designated controllers maintain an operational overview of the evolving air and ground traffic situation in each of the Toronto ATS units during busy periods (CASB 88-18). The Minister's response to this recommendation stated that Transport Canada is developing an operational plan to provide an increased operational overview capability in all ACCs and major towers. This plan will increase supervisory personnel complements at selected locations. Although this initiative will ultimately result in an increase in staffing levels at these units, real increases in available staff are some distance off. Increasing establishment levels is only the first step in addressing the shortage of qualified controllers; it will also be necessary to find and train the additional personnel.

On 18 August 1989, the Minister of Transport announced a series of initiatives to deal with the increasing air traffic in the southern Ontario region. Among these initiatives were the continued recruitment of experienced air traffic controllers from other jurisdictions and expansion of the annual enrolment in Transport Canada's Air Traffic Services Training Centre to over 300 trainees from the current annual intake of 216 trainees. This initiative has potential to provide some relief in the mid- to long-term. However, given the current lead time necessary to fully train an ab-initio controller candidate, and the historic high attrition which occurs during training, near-term net change in the number of controllers available to work sectors will be minimal.

Notwithstanding the recent initiatives designed to relieve the current staffing crisis, a timely recovery will require a more concerted effort on the part of Transport Canada to find and adopt new and innovative strategies. Strategies worth exploring include further changes designed to streamline the training process, further incentives to attract controllers to the most critically short units, and closing of under-utilized facilities coupled with redeployment of manpower resources to where they are most needed.

Undoubtedly, there are other potential solutions which could offer more timely resolution of the staffing shortage. Transport Canada must explore these options with vigour and not restrict the search for solutions to tried and tested measures. Innovative solutions will be required.

5.3 SAFETY IMPLICATIONS

The potential safety implications of inadequate staffing are wide-ranging. Single controller sectors, sector consolidation, increased controller workload, the requirement for significant overtime, reduced availability of relief breaks can all detrimentally effect the safety of operations.

The CASB file review of 217 loss of separation incidents identified staffing-related factors in 94 (43 per cent) of the incidents analysed. The following example illustrates one occurrence where inadequate staff was attributed, in part, to a loss of separation.

> On 02 September 1987, a loss of separation occurred 12 miles southeast of Toronto involving a Douglas DC-3 and a Falcon 50. The DC-3 was eastbound, en route to Oshawa at 7,000 feet; the Falcon was northbound, inbound to Toronto and had been cleared to 7,000 feet. The aircraft passed on crossing tracks with less than one mile horizontal separation following evasive action initiated by an air traffic controller.
>
> The ATS Fact Finding Board held after the occurrence found that the key element which precipitated the loss of separation was the failure of the coordinator to provide required information on the DC-3 to the arrival controller. At the time of the occurrence, traffic volume within the Terminal Specialty was high and very complex. However, the Fact Finding Board concluded that, in consideration of all factors, the loss of separation had been caused by an ATC system that allowed the traffic volume to increase past the point whereby it could be safely controlled given present procedures, equipment, and staffing levels. At the time of the occurrence, the Terminal Specialty was operating one controller below the established unit staffing minima.

NATIONAL STAFFING PLAN

	1/4/88	1/4/89	1/4/90	1/4/91	1/4/92	1/4/93	1/4/94	1/4/95	1/4/96
I. Strength Profile Attrition - 86 per year til 92/93 - 60 per year, after Others - CAATS 11/TCTI 16	1944	1837	1751	1659	1573	1513	1453	1393	1333
II. Baseline Requirements	1943*	1982	2000	2012	2012*	2012	2012	2012	2012
Strength/Requirement Variance	1	(145)	(249)	(353)	(439)	(499)	(559)	(619)	(679)
III. Expected Training Output Capacity *** Annual Cumulative		45 45	77 122	103 225	103 328	103 431	103 534	103 637	103 740
Expected Controller Shortfall	1	(100)	(127)	(128)	(111)	(68)	(25)	18	61
IV. External Recruitment *** Annual Phase 1 Cumulative			30 30	15 45	0 45	0 45	30		
Adjusted Shortfall	1	(100)	(97)	(83)	(66)	(23)	5	18	61

As of 1989

*

** TCAG approved 88/89 establishment level including 36 P.Y. for Err.

*** Growth beyond 1992/93 has yet to be determined.

The Cumulative figure is used to calculate "shortfall".

Table 5-2

5.4 STAFFING PROGNOSIS

Current staffing forecasts see little improvement in the near-term. Although efforts are now underway to speed recovery, staffing in the ATS branch will be many years on the mend. According to a 1988 Air Traffic Services Staffing Plan (see Table 5-2), it will be at least 1994 before the system fully recovers from the current staffing crisis. In fact, the controller shortfall is expected to get worse before recovery commences. However, the forecast assumes no growth in baseline controller requirements beyond 1991. Continued traffic growth into the 1990s may make this assumption invalid. Furthermore, based on previous experience, the expected training output used in the staffing plan may be overly optimistic.

A significant number of controllers, supervisors, and managers interviewed during the field survey phase of the investigation were of the opinion that the situation may get much worse before improvement is seen. They foresee significant increases in controller attrition during the next several years. This attrition will be highest at the units currently experiencing the most severe shortages. Stress and "burn-out" associated with the current high workload were cited as the driving forces behind the desire of many experienced controllers to opt for early retirement or a career change. The potential for high attrition rates among experienced controllers is made greater by the increasing average age of controllers. At some sites, in particular Toronto ACC, the average age of controllers is 45 years or greater. As a result, many are in personal and/or financial positions where they can opt for a career change or are taking their retirement. At Toronto, there was a loss of nine operationally qualified individuals to retirement and/or career changes during the first three quarters of 1989. (In addition, six controllers were not available for operational control duties for an indeterminate period for medical reasons.)

Improved equipment (such as the Radar Modernization Project, new controller work stations, Mode-S data transfer, etc.) will undoubtedly increase individual controller productivity; before the turn of the century, however, it seems likely that, barring a major slow-down, air traffic will increasingly strain the available controller workforce in the interim. Therefore, continued use of overtime to make up for staff shortages and further traffic restrictions may be the only alternatives available to keep the system operating.

It is always difficult to second guess what the future may hold in an area as dynamic as civil aviation. Past economic slow-downs have tended to impact air traffic figures very quickly, and when this occurs, managers of the ATC system have invariably found themselves with large and expensive systems not being utilized to their maximum.

This said, however, history is once again demonstrating that, unlike many industries able to hire from "the street" with a minimum of training, it is simply not possible to react to a staffing shortage in ATC in any rapid way. While it may be relatively easy to identify surplus in lean years, the complexities of federal government staffing policies, with their diverse programs ranging from re-employment (Work Force Adjustment Policy), to security standards, to employment equity programs for under-represented groups, significantly impact on and can retard the process - even when hiring is urgently required. In addition, staffing models must take into account the need for ongoing training, as well as allowing for a proportion of non-effective positions due to controllers on maintenance-of-salary, long-term disability, and staffing delays.

Had the Program Control Board and the Personnel Branch respected the timetable of rehiring put forward in the 1984 Multi-Year Operational Plan, today's staffing problems would have been in large measure avoided. Notwithstanding the unexpected growth in air traffic over the past year, the present shortage of staff could have been minimized had recruiting and training commenced earlier than June 1987. It appears that the Departmental priorities were heavily influenced by initiatives related to:

- Major reorganization within the Aviation and Personnel Groups.
- Government policy/directives regarding downsizing.
- Anticipated contributions by the ATS Branch to overhead reductions.

Any slowing down of the process of hiring and training which is now underway will have detrimental effects on the welfare of present personnel, on the system capacity and ultimately on its safety. If use of sick leave were to increase dramatically or if any other factor were to affect staffing levels in a negative way, it is possible that, at some locations, sectors would need to be closed on a semi-permanent basis.

In summary, human resource planning and staff allocations within the ATS Branch have been difficult and frustrating exercises during the last 10 years. There have been almost continuous reviews, audits, studies, and downsizing efforts. Clearly, there is a need on the part of corporate management to recognize that as air traffic grows, there will be peaks and valleys in the demand for ATC services. Due to the lead-times required for recruitment and training of new controllers, it is unrealistic to expect peak efficiency in the utilization of the ATC workforce at all times. (Chapter 11, Management further addresses the staff planning issue.)

5.5 CONTROLLER WORKLOAD

5.5.1 General

Personnel establishments (staffing levels) for ATC are determined almost exclusively by workload. Depending on the type of unit, workload comprises several different ingredients, but traffic counts (traffic volume) play the principal role.

5.5.2 IFR Workload

In the case of IFR controllers, complexity is also a major factor in determining workload. For the IFR controller, complexity might mean a complicated route structure with several crossing tracks, or control of IFR operations at a number of different airports in proximity to each other, with conflicting approach patterns. Limitations of the equipment and the amount of inter-unit and inter-sector coordination are two other factors which affect workload. In assessing workload, all factors must be taken together to determine their overall impact on workload and ultimately on overall system capacity.

Workload for individual units and subunits is regularly reassessed by ATS headquarters. For an IFR unit, a Pace Level rating system has been designed to provide a scale of "busyness" from value one to value seven. Value one indicates very low activity; value seven indicates near traffic saturation, extreme demands in the areas of control decisions, coordination and communication, and generally, places demands on systems to a point beyond which, a total collapse would likely occur. Pace Level five has been assessed to be the optimum level of activity for a controller working an IFR sector. Research has determined that, at this pace, controller attention is focused, decisions and control action must be taken frequently, and the traffic flow is orderly and expeditious. (See Annex A to this Chapter for a more detailed description of Pace Levels.)

5.5.3 Airport Control Workload

At an airport control tower, workload is measured in quite a different way since there is a completely different set of factors affecting the workload of tower controllers. However, no comparable system to the Pace Level rating system exists for quantifying airport control workload. In 1987, the Canadian Airspace Review recommended that Transport Canada develop workload measurement criteria for control tower positions (CAR 7.1.1.01). To date no action has been taken to implement this recommendation.

Nevertheless, whereas a complex airspace structure is a very important consideration for an IFR controller, a VFR controller's workload is far more likely to be affected adversely by, for example, a runway that is not supported by an accompanying taxiway or by the terrain in the vicinity of the airport. In determining the workload of an airport controller, these factors and many others would be considered in their proper context.

5.5.4 The Work Day

The ATC system in Canada operates 24 hours a day, 365 days a year. Thus it is necessary for ATC units to schedule their employees to work a number of different shift patterns. The specific terms and conditions of employment for air traffic controllers are governed by a collective agreement between the employer (Treasury Board) and the bargaining unit (Canadian Air Traffic Controllers Association). In accordance with the collective agreement, the basis for all shift cycles is a 34-hour work week. The standard shift cycle is a series of repeating cycles during which a controller will work a shift on five consecutive days followed by four days of rest then a further five consecutive days of work followed by three days of rest (5-4, 5-3). Shift cycles are made up of a sequence of day shifts, evening shifts, and midnight shifts. Although the collective agreement specifies this standard shift cycle, managers have been permitted considerable flexibility over the years, provided that any changes respect the intent of the contract. Changes to a cycle of work are negotiated between local management and representatives of the controllers' association. (Chapter 9, Human Performance Factors further addresses the effects of shift cycles.)

The following are the shift cycles worked by the four sites visited by the investigation team;

i) Vancouver and Montreal; 5-3, 5-4; a 17-day cycle of 8 hours and 15 minutes per day,

ii) Gander; 5-3, 5-4, 6-4; a 27-day cycle of 8 hours and 15 minutes per day, and

iii) Toronto; 5-4; a 9-day cycle of 8 hours and 45 minutes.

Other provisions of the collective agreement prohibit shift scheduling for periods exceeding 12 consecutive hours, and shift cycles exceeding nine consecutive days of work.

5.5.5 Workload Today

The total workload within the ATC system has risen dramatically in the past five years. Traffic growth has been significant, and it has been accompanied by considerable increase in traffic complexity. As previously discussed, this increase in total workload has not been accompanied by a corresponding increase in the number of air traffic controllers.

To a certain extent, Transport Canada has responded to the shortage of controllers by developing procedures which will permit the flow to be regulated when it approaches Pace value seven for any given sector. This has been the case at Toronto's LBPIA and to a lesser degree at Vancouver International Airport. Although the Terminal Specialty sectors of the ACCs are generally the sectors most likely to require flow control restriction due to near saturation, this problem is not uniquely theirs. On occasion, for example, the North Subunit of the Montreal ACC restricts the westbound flow from Europe due to a significant staff shortage in their sectors which has occurred as a result of a sudden increase in traffic further to the north over the North Atlantic.

However, it is not always possible to impose flow restrictions because of ripple effects experienced elsewhere in the ATC system. For example, flow restrictions imposed in the North Subunit of Montreal ACC create operational headaches for Gander ACC and, in turn, Shanwick Control in Great Britain. Since aircraft cannot practically be held over the North Atlantic, flow control measures applied by Montreal ACC on the westbound flow have a ripple effect that will often reach the point of departure in Europe many thousands of miles away.

Although flow restriction measures have to a certain extent permitted the ATC system to balance workload with available controllers, the current staffing levels within the ATC system have meant an increase in workload for individual controllers.

As previously indicated (see Chapter 3, Analysis of Canadian Incidents), "workload" was identified as a element in 35 of the 217 loss of separation occurrences examined in the file review. The following is another typical example of the impact of workload and staffing on safety:

> On 06 October 1988, a loss of separation occurred between a Boeing 737 and a Mooney 21 while both aircraft were on final approach to land at Vancouver International Airport. Both aircraft were conducting the ILS approach to runway 26; the Boeing 737 was following the Mooney. After hand-off to the airport controller, the spacing between the aircraft reduced to 1.8 miles before the Boeing 737 was instructed to execute a missed approach.
>
> The ATS Fact Finding Board convened following the occurrence determined that the cause of the loss of separation was the failure of the Arrival Low controller to maintain required vigilance to ensure that appropriate lateral separation (three miles) between the two aircraft was maintained.
>
> At the time of the occurrence traffic volume within the Arrival Low sector was heavy and very complex. The Arrival Low controller was working at Pace Level 6. Staffing within the Terminal Specialty was one less than required by unit policy.

5.6 OPENING AND CLOSING OF SECTORS

The condensing (or combining) and opening of sectors is the primary method to accommodate changes in traffic levels thereby evenly and appropriately distributing controller workload. The capability to easily combine two sectors into one, or open a sector that was previously combined with another, was deliberately designed into the ACC automated equipment. This feature facilitates the closing of a sector in which traffic is sparse, and the reassigning of responsibility of this area to an adjacent sector. Conversely, when traffic increases resulting in a consequent increase in workload, previously combined sectors can be split to distribute what would be an excessive workload for one controller. In this manner, controller workload can be kept near the optimum Pace Level. In any given day, within each operational ATC unit, there is normally a steady rhythm of opening and closing sectors in response to the daily peaks and valleys in traffic volume and complexity.

Sectors can be combined in a variety of ways. Data positions can be combined with radio or radar positions, two geographically adjacent sectors can be combined into one larger sector, or two sectors which cover the same geographical area, but at different altitudes, can also be combined. Normally, at a Pace Level between four and five, a sector should not be combined with another and staffing should be at the norm required by the sector.

Frequently, it is necessary to re-examine and modify the sector configuration within an ATC unit in response to the increased traffic levels or to changes in the character of the traffic. Normally sector re-configuration is accomplished by assessing traffic levels against the Pace Level workload measurement system. Where traffic levels have significantly increased, re-sectorization invariably results in the creation of additional sectors. At Toronto for example, re-sectorization has recently resulted in the addition of one additional position in the West Specialty. Other changes are currently being contemplated in the East and Terminal specialties.

Staff shortages at some ATC units now mean that it is not always possible to have enough controllers on duty to staff the requisite number of sectors corresponding to the traffic volume and complexity. When this occurs, there remains little option but to close a sector by combining it with another. This can result in an unmanageable build-up of traffic, and hence workload, over the course of the shift. During the field survey phase of the investigation, many controllers expressed the view that short staffed sectors can be a veritable trap, stating: "...traffic builds up and before you realize it, you find yourself in a situation where you need assistance and there is none available!"

A significant number of loss of separation occurrences which were identified in the file reviews as having "inadequate staff" as a cause factor involved combined sectors. Following is an example.

> On 03 September 1987 a loss of separation occurred between a Boeing 747 and a Lockheed 1011 operating in high-level airspace over northern Saskatchewan. The Boeing 747 was en route to New York from Anchorage, the Lockheed 1011 was en route to Calgary from Frankfurt. Both aircraft were operating at FL370. The loss of separation occurred when the two aircraft crossed tracks with only two minutes spacing at the crossing point, vs. the required 15-minute separation.

> The Fact Finding Board determined that the primary cause of the loss of separation was the failure of the responsible controller to check the entire route of the Boeing 747 for conflictions prior to issuing a clearance for the aircraft to climb to FL370.
>
> At the time of the occurrence, traffic within the applicable sector was assessed as heavy and very complex. The controller had become involved in an unrelated aircraft emergency approximately 20 minutes before the Boeing 747 was cleared to FL370. As a result of the workload level, the controller was unable to keep up with data board functions to the point that he was unable to maintain a complete picture of traffic within his sector. The data and radio positions were combined at the time; Pace Level was assessed to be 6 or greater.

Controllers have also expressed concern over the way in which sectors are closed and opened. Although supervisors are ultimately responsible for combining and opening sectors, it is a commonly held view that staff shortages in many areas have made exercising this responsibility practically impossible.

5.7 RELIEF AND REST PERIODS

With the shortage of personnel in certain subunits, it has become increasingly difficult to provide controllers with adequate relief breaks.

In the 1982 Resource Alignment Project conducted by the ATS Branch, the following conclusion was drawn following IFR workload evaluations conducted at the Research and Simulation Centre between January and March of that year :

> It is recognized that 92 hours of data constitute a somewhat limited sampling; however when supplemented by hundreds of hours of on-site observations which support the same conclusion, it is realistic to consider that for planning purposes the British practice of two hours at a control position with Pace Levels of 5-6, is reasonable.

Although specific details of rest periods are not outlined in the Treasury Board/CATCA (Canadian Air Traffic Control Association) collective agreement, the subject is discussed in article 13.01 (b) thus :

> Where operational requirements permit, the Employer will provide operating employees with meal and relief breaks.

During the interviews, controllers across the country commented on the subject of rest periods. There was general accord among all - both IFR and airport controllers - that breaks are essential at between 1.5 and 2.0 hours. Longer periods of work, especially work involving concentrated demanding effort, result in a rapid slowing-down of the decision process, a distinct degradation of alertness, and a difficulty in forming verbal messages.

There was a consensus among controllers and supervisors interviewed during the field survey phase of the investigation that the current staffing situation is having a detrimental effect on the allocation of rest and relief breaks. Increased traffic levels and the consequent increase in workload for controllers have been accompanied by a gradual erosion in the time available for rest and relief breaks. All controllers recognize that there are special circumstances during which normal rest periods cannot be permitted. Thunderstorm activity with its inevitable rerouting and holdings during the summer, and winter blizzards with the resulting delays to traffic and missed approaches, are but two examples of special situations during which workload is often very heavy and the routine operation in terms of rest periods is set aside. However, in the eyes of many, special circumstances have now become the routine.

Following a loss of separation occurrence investigated by CASB, the controller wrote:

> "There were only two controllers on duty even though the unit qualified for three controllers and an assistant at the time of day in which the incident occurred. I ate my supper while working the airport control position because it was the quieter of the two positions. It was the position from which I felt I could continue to function while eating a meal. It is now evident that no position in an air traffic control unit is as safe when being staffed by controllers eating meals."

The provision of adequate rest and relief breaks can be particularly difficult during the peak traffic periods of the day when workload requires that all, or nearly all, sectors be open. Ironically, it is when workload and work demands are highest that rest and relief breaks are most important. At those units with the most critical staff shortages, there may already be too few controllers to staff the required sectors. Although management attempts to schedule extra staff during the busy periods of the day to allow for rest and relief breaks, often the extra staff are not available. Thus, releasing a controller from his position in order to provide a needed break may require further combining of sectors, and a resultant increase in the workload of the remaining controllers.

Although the following occurrence may represent an isolated circumstance, the lack of relief breaks is cause for concern.

> On 24 September 1987, a Cessna 402 was northbound from Victoria to Vancouver at 3,000 feet. At the same time, a Sikorsky S76 was southbound from Vancouver Harbour to Victoria, also at 3,000 feet. The aircraft were approximately one-half mile apart travelling in the opposite direction, at the same altitude when the S76 was instructed to turn left immediately. The radar controller reported that the radar targets of the two aircraft merged before appropriate separation was regained.
>
> At the time of the occurrence, traffic in the Vancouver Terminal Specialty was assessed to be heavy and very complex. Pace levels for five of the seven open positions were assessed to be 6.5 or above. These pace levels had been sustained for several hours.
>
> The ATS Fact Finding Board determined that controllers on shift at the time had worked up to five and one half hours with as little as a 10-minute break.
>
> The Arrival High controller had been on duty for approximately four and one half hours and was working the Arrival High sector for 40 minutes prior to the occurrence. He had had a 30-minute relief break since the commencement of his shift.
>
> The Departure controller had been on duty for approximately three and one half hours and was working the Departure sector for one hour prior to the occurrence. He had had a 10-minute break since the commencement of the shift.
>
> The Terminal Data controller had been on duty for approximately one and one half hours and had worked this sector from the commencement of his shift without relief break.
>
> The Victoria Radar controller had been on duty for approximately three and one half hours and had been working the Victoria Radar sector for 40 minutes prior

> to the occurrence. He had had no relief break since the commencement of his shift.
>
> The Victoria Data controller had been on duty for approximately four and one half hours and was working the Victoria Data position for 10 minutes prior to the occurrence. He had had a 10-minute relief break since the commencement of his shift.

Given current staffing shortages, the difficulties experienced in providing relief and meal breaks are clearly illustrated by the circumstances surrounding the following loss of separation.

> On 24 January 1988, two Boeing 737s passed with less than the minimum separation approximately 20 miles south of Vancouver. One aircraft had departed Victoria and was climbing north-eastbound, en route to Calgary; the second aircraft had departed Vancouver and was climbing southbound, en route to San Francisco. The aircraft came within two miles of each other with less than 100 feet vertical separation at about 12,700 feet.
>
> The ATS Fact Finding Board held following the occurrence found that the loss of separation had been caused by the failure of the Victoria sector controller to inform either the Vancouver Data or Departure controller of required information pertaining to the 737 which had departed Victoria.
>
> The Fact Finding Board also found that, at the time of the occurrence, the data and radar positions of the Victoria sector had been combined. Pace level was determined to be such that both the data and radar positions should have been manned. Staffing at the time included four controllers and one supervisor. The approved staffing level for the Terminal Specialty was six controllers. Attempts to call another controller for overtime had been unsuccessful. One controller was on a relief break at the time of the occurrence. The supervisor had been reluctant to call back a controller from a relief break when his assistance was required. The controller on relief break had been out of the operational area for 10 minutes after having worked a sector for one and a half hours.

5.8 OVERTIME

5.8.1 Staffing and Overtime

The present shortage of controllers has meant that, to maintain levels of service at par with demand, management has been forced to rely increasingly on overtime. The net effect of this increasing reliance on overtime has been a significant increase in the number of shifts worked by some controllers, and a corresponding decrease in the number of days off.

In the eyes of many, overtime has become the glue that holds the ATC system together. There is strong consensus among controllers, supervisors, and some managers that, in certain cases, the situation is rapidly nearing safe limits. Many hold the view that the hours worked by some controllers are excessive and that the number of days off for these controllers is inadequate. They believe that, if not already compromised, continuance of the current overtime situation will seriously compromise air traffic control safety.

To date, with limited exceptions, the ATS Branch has not had to resort to mandatory overtime; overtime worked by controllers is done on a voluntary basis. There is a small number of controllers who will not work any overtime. However, by and large, the majority of controllers do volunteer for overtime shifts, and there are a significant number who work, what is in the opinion of many, an excessive amount. Although voluntary in nature, many controllers feel compelled to work some overtime. At short-staffed units and subunits, there is a feeling among some that when one refuses to work overtime, the other members of the team carry an additional load by working short staffed. To quote one controller: "..in consideration of each other, we will, as much as possible, work when needed."

Although feedback at the unit level is that the hours of work for some controllers are excessive and that continuance of the overtime situation will compromise air traffic control safety, ATS management report that they are "with few exceptions, left with the abiding conviction that controllers are not overworked."

In support of this conclusion, ATS management cited a study they had conducted at Toronto ACC and Toronto Tower (PIA) which determined the number of days worked and the number of days off, for whatever reason (leave, sick leave, normal days off), for controllers during the period 01 June 1988 to 30 November 1988. Averages for the applicable subunits were determined as follows:

Subunit	Days worked	Days off
East Subunit	91	93
North Subunit	97	76
West Subunit	98	76
Terminal Subunit	99	80
Toronto Tower	94	81

Upon completion of this study, ATS management noted that some controllers worked more overtime than others and, as a result, asked the General Manager of the Toronto ACC to deal with this on an immediate basis.

Shift and attendance records for three ATC units were examined during the course of this Special Investigation. For Vancouver ACC, overtime shift records for the months of February 1989 and March 1989 were examined. In February 1989, the average number of overtime shifts worked per controller in the East, West and Terminal specialties was 3.4, 5.3 and 3.2 respectively. In March 1989, the average number of overtime shifts in the East, West and Terminal specialties was 3.5, 6.1, and 1.9 respectively. However, numerous controllers were found to have worked well over the average number of overtime shifts. Seven or eight overtime shifts in one month were not uncommon. In the months preceding February and March, several instances of 11 overtime shifts in one month were observed. In the case of one terminal controller, overtime shifts for each month in the four-month period October 1988 through January 1989 inclusive numbered nine, nine, eleven and eleven respectively. These overtime shifts would be in excess of the approximate 18 regular shifts that would be worked in a 30-day period in accordance with the 17-day 5-4, 5-3 work/rest cycle in use at Vancouver. Thus, it was not uncommon for controllers to be working 25 or 26 shifts in a 30-day period, with some working as many as 28 shifts.

For Toronto ACC, attendance records for the month of April 1989 were examined. The average number of shifts (regular and overtime) worked by each controller was 21. However, as in the case of Vancouver, there was a significant number of controllers who worked well over the average number of shifts. Twenty-four to 26 shifts in the month were not uncommon; at least three controllers had worked 27 shifts in the 30 day period. Several instances of controllers working in excess of nine consecutive (the maximum specified in the collective agreement) days were found. In at least two cases, controllers had worked shifts on 17 consecutive days. There were other instances where controllers had worked nine consecutive days followed by one day off, followed by another nine consecutive days of work.

For Toronto Tower, attendance records for the month of April 1989 were also examined. The average number of shifts (regular and overtime) worked by each controller was 20. There were some controllers who had worked as many as 24 shifts in the 30-day period. One instance of a controller working 16 days straight was observed.

Although, on balance, the controller work force as a whole does not appear to be working an excessive amount of overtime, it is clear that a significant minority of controllers are working what must be considered an excessive amount, with an inadequate number of days off.

5.8.2 Impact of Contractual Provisions

There is considerable consensus, even among working controllers, that the controllers themselves must share significant responsibility for the amounts of overtime being worked. There is a general acceptance that contractual provisions between the employer and controllers have become a significant incentive to work overtime, in particular, multiple shifts on consecutive days. In fact, many hold the view that overtime compensation provisions of the collective agreement are part of the overtime problem, in that they financially encourage abuse. Surprisingly, controllers themselves readily acknowledge that personal greed is a significant element in the overtime problem.

The collective agreement under which controllers work stipulates a sliding scale for the rate of remuneration for hours worked in excess of the normal shift cycle. Normally, a controller who works overtime on a day of rest is paid at one and one half times the normal rate of pay. However, if the overtime is worked on two consecutive days of rest, pay is at twice the normal rate for the hours worked on the second day. If the overtime is worked on three or more consecutive days of rest, pay is at two and one half time the normal rate for the hours worked on the third day and any subsequent consecutive days of rest. Other collective agreement provisions prohibit controllers from working more than nine consecutive days, and specify a minimum of eight hours of rest between shifts.

As a result of overtime remuneration provisions, there is considerable financial incentive for controllers to work multiple consecutive days of overtime. Originally designed to be a disincentive to management to rely on overtime, the remuneration provisions have become a bonanza for controllers desiring to substantially increase their income.

Controllers determined to exploit the overtime situation have devised cooperative plans with their colleagues which see a creative use of shift changes combined with sick leave to work the absolute maximum of overtime shifts. For some, the objective is to work overtime only when three or four consecutive shifts can be worked, thereby maximizing the financial gain. At some units, shift trades among individual controllers are made to ensure a continuous string of working days to maximize overtime remuneration. In some instances controllers have worked their normal five-day cycle, followed by five, six or even seven overtime shifts in their scheduled four days of rest. At one ACC new terminology has emerged to describe consecutive days of work:

Small slam - three overtime shifts in three consecutive days

Grand slam - four overtime shifts in four consecutive days

Mega slam - five to seven overtime shifts in four consecutive days

Interviews conducted during the field survey phase of the investigation indicate that controllers expect on average to work four to five overtime shifts per month. There were, however, some controllers who indicated that their overtime shifts averaged near 10 per month. For these controllers the financial incentives were clearly the most significant motivating factor. To quote one controller, "I intend to work all the overtime available which should average over 15 shifts per month. In a couple of years I will retire and start a business".

There was clear consensus among those interviewed that financial incentives to work excessive overtime must be eliminated. A single rate of overtime remuneration was commonly suggested. Many also held the view that the collective agreement was an ineffective tool in managing overtime. Although maximum consecutive days of work and maximum hours of work per shift are specified in the contract, on occasion, individual controllers exceed these limits, with the apparent tacit approval of unit management. Many were of the view that there is a real need to introduce regulations which establish maximum hours of work and minimum rest periods for controllers, similar to those that currently exist for pilots involved in commercial air operations.

5.8.3 Overtime Effects

To a certain extent, overtime causes more overtime. For example, the collective agreement prohibits a controller from working more than nine consecutive days. Thus, if a controller works five days of a normal cycle followed by four days of overtime on his scheduled rest days, he must receive a paid day off on what would have been the first working day of his next cycle. Since he cannot work, a further overtime requirement/opportunity is created for another controller. Furthermore, there was a general feeling that cycles of nine consecutive days at work, result in an increase in sick leave, which, in turn, creates more overtime. Unfortunately, the Investigators were unable to quantify this effect.

It was the view of a considerable number of controllers, supervisors, and managers interviewed during the field survey that today's overtime situation is either increasing, or will likely increase, attrition among the ranks of experienced controllers. They cite the increased stress levels associated with longer working hours and less time off as a significant factor in many controllers' decisions to leave the field of air traffic control. Thus, today's heavy reliance on overtime may, in the long run, end up exacerbating the current staff shortage. In the words of one controller, "staff shortages result in more burn-out, earlier retirement, and again less staff."

Controller fatigue, and its potential impact on safety, is the overriding concern expressed by those who believe that overtime has become a significant problem. The following example illustrates a loss of separation in which excessive hours of work and the resulting controller fatigue were likely contributing factors.

> On 10 January 1989, a Douglas DC-9 on final approach to runway 24L at Toronto LBPIA was involved in a loss of separation with British Aerospace Jetstream 31 on radar vectors for the approach to runway 24R at LBPIA.
>
> The DC-9, inbound from Montreal, was established on the localizer for runway 24L at 4,000 feet, and had received clearance for the approach. The Jetstream 31, inbound from Dayton, Ohio, was north of the airport, on vectors for the approach for 24R, descending to 4,000 feet. At about 15 miles northeast of the airport, the Jetstream 31 was instructed to turn right to a heading of 170 degrees. No further heading instructions were passed to the Jetstream 31, and it proceeded through the runway 24R localizer. The controller had diverted his attention to other traffic and did not detect the conflict between the DC-9 and the Jetstream 31 until the crew of the Jetstream questioned crossing the localizer. Fortunately, visual meteorological conditions prevailed and the crew of the Jetstream had visually sighted the DC-9 and levelled their aircraft 500 feet above the altitude of the DC-9. The two aircraft converged to within three-quarters of a mile horizontally and 400 feet vertically.

> Traffic at the time was heavy and complex. Twelve aircraft were operating under the responsibility of the Arrival controller. The volume, complexity and routing of inbound traffic placed the controller in a position where a high degree of concentration and monitoring was required. The Arrival controller was working his seventh consecutive day and fourteenth day in the last 16 days.

The problems associated with fatigue and the role of overtime in fatigue development are discussed in more detail in Chapter 9, Human Performance Factors.

To date, ATS management has seen no requirement to alter its current practice of voluntary overtime. They acknowledge that some controllers work more overtime than others; however, at the present time, they do not see the requirement for change; e.g., mandatory overtime in order to achieve a more equitable distribution.

5.9 OBSERVATIONS

1. The ATS system is experiencing critical staff shortages which are particularly acute in the Toronto, Vancouver, Montreal, and Gander Area Control Centres.

2. The current staffing situation is the result of a convergence of factors and events which unfolded in the early to mid-1980s which have had a serious cumulative impact in the late-1980s.

3. ATS human resource planning during this period was frustrated by Transport Canada's efforts to reduce staffing overhead as a result of reduced air traffic, concurrent government-wide downsizing initiatives, and federal government staffing policies.

4. Staffing shortages will likely increase before significant improvement occurs.

5. Staffing-related issues were found to be present in 43 per cent of incidents examined in the file review.

6. First-line supervisors report that they are manning active control positions for up to 90 per cent of their duty time.

7. Current Transport Canada staffing initiatives will not significantly improve the staffing situation in the near-term.

8. Insufficient incentives exist to attract qualified controllers to the units where the most serious shortages exist. In fact, the opposite is true; serious disincentives are present.

9. Timely resolution of the current staffing shortage will require innovative solutions. Reliance on tried and tested methods will not result in the increase in staff that is now necessary.

10. There is concern that current staffing shortages are making it difficult to provide controllers with adequate rest and relief breaks.

11. Current staffing shortages have resulted in extensive reliance on overtime; indeed, without management's complete reliance on voluntary overtime today, the ATS system would be unable to cope with current demands for service.

12. While the majority of controllers are working some overtime, some controllers are volunteering to work what can only be described as excessive numbers of shifts.

13. On occasion, provisions of the collective agreement regarding maximum consecutive days of work are not enforced; both Transport Canada management and the professional association (CATCA) appear to implicitly condone current excesses.

14. Overtime rates of pay provisions of the collective agreement provide financial incentives for controllers to work excessive overtime, in particular multiple overtime shifts on consecutive days.

15. Excessive reliance on overtime presents serious potential for controller fatigue and may exacerbate the staffing shortage by increasing controller attrition.

16. To date, ATS management has seen no requirement to alter its current practice of voluntary overtime. There is no evidence that a more equitable distribution of the overtime required is being pursued.

ANNEX A

PACE LEVEL DESCRIPTION
(Degree of "Busyness")

Level

1 Watch keeping only, minimal to nil control decisions. Volume typically very light (i.e., five per hour) well spaced in time or geography. No complexity.

2 Occasional attention required, infrequent requirement for control decisions. Volume very light, occasional tactical action (vectors/restrictions) required for separation. No complexity.

3 Most inactive, however, frequent brief periods required for control decisions. Minimal to nil preplanning requirement. Volume light (i.e., eight per hour) some tactical action required for separation. Occasional complexity may be apparent.

4 Traffic requires frequent control decision/actions (some periods of inactivity occur). Some preplanning required. Traffic warrants attention of controller majority of the time. Time available for lengthy coordination requirements, flight plan inputs, preparation of hand-written strips, etc.

5 Operation of sector/position requires continuous attention. Traffic flow is orderly and expeditious (excluding external factors). Preplanning is required and time is available to do so. Complexity is normal (i.e., not causing undue concern). Coordination is timely and complete. Unusual situations such as an airfile would be accommodated but probably not immediately. Time available for full flight information services.

6 Traffic demands continuous and complete attention. Preplanning is an ongoing requirement. Full flight information services may not be provided due to workload, communications, congestion, etc. Airfile would probably not be accommodated during this period. Signs of periodic anxiety may be apparent. Communications and coordination may occasionally be untimely.

7 The frequency of control decisions, coordination and communications is demanding to the point of straining the position/sector beyond its capability, and, if this heavy demand is sustained or increased, a complex breakdown would occur. Flight information routinely not provided. Flow may be becoming disorderly. Probably some control transfers are not timely. Coordination probably not as complete or timely as would be normal. Flow control measures may be

implemented. Extraordinary requests/situations would likely require assistance (i.e., supervisor). A sustained period of this level of activity would be approximately 20 to 30 minutes.

NOTE: Volume figures are for internal descriptive purposes only. Volume should not be used for rating purposes, rather the impact of the traffic equated to workload is to be assessed.

CHAPTER 6

TRAINING

6 INTRODUCTION

Transport Canada has in place an ATS Training Program with an objective to "develop, maintain, and improve, on a continuing basis, during the career of each individual, the technical skills and proficiency required by the ATS Branch."[1] This program consists of several elements. These include Basic controller training at the Air Traffic Services Training Centre at Cornwall, Ontario; Qualification training to license standard at the region/unit level; Conversion training for already licensed controllers transferring from one unit to another or from one specialty to another; and Refresher and Familiarization training.

Before any ATC license can be issued to a person, that person must have successfully completed both the basic course and qualification training.

6.1 RECRUITMENT AND SELECTION

Policies and procedures for the recruitment and selection of prospective air traffic controllers are developed at the national level within the ATS Branch. However, the actual responsibility for controller recruitment and selection has been delegated to Regional Managers of ATS and General Managers of the ACCs. Within each Region, a Human Resources Committee has been established to coordinate the recruitment and selection requirements of the ACC and its affiliated control towers and stand-alone units. This committee, normally chaired by the General Manager of the ACC, is tasked with filling the training positions allocated to the Region. Each Region is allocated a specific number of basic training positions at the ATS Training Centre on an annual basis. This allocation is determined by Transport Canada Headquarters in Ottawa, in consultation with the Regions.

Candidates selected for ATC training must meet selection criteria that include established standards for medical fitness, security clearance requirements, and acceptable scoring on a screening test that parallels the American Multiple Controller Aptitude Test (MCAT). In addition, prospective controllers are subject to a structured interview with input from developmental psychologists. Desirable attributes are good comprehension and communication skills, the ability to perform under pressure, quick and accurate decision-making, good concentration, self-motivation, and cooperation skills.

6.2 PRE-LICENCE TRAINING

6.2.1 Basic Training

The basic training course is designed to provide candidates with sufficient knowledge and skills to enable them to commence Qualification Training for any one of the specialties - airport, area, or terminal control. It encompasses theoretical lessons and practice exercises in various simulators. Students are provided:

- a broad theoretical background in subjects related to the provision of air traffic services;
- in-depth coverage of the knowledge required to function as airport, area, and terminal controllers; and
- the opportunity to exercise their knowledge and develop basic ATC skills in a synthetic environment.[1]

The Basic course also serves as a further selection function in that it provides a process for measuring student performance and evaluating potential for ATC duties.

The Basic course is arranged in four separate parts:

Orientation	- Overview of the Department, Branch, job, and training
Segment 1	- Low altitude non-radar IFR control
Segment 2	- High altitude non-radar IFR control, Area control - radar and non-radar, meteorology.
Segment 3	- Airport control and Direction Finding (DF)

Until recently, total duration of the Basic course was 177 training days. However, changes to the Basic syllabus implemented in 1989 reduced course length by 14 training days. Further reductions in course length are planned for January 1990.

Ten Basic courses are scheduled each year at the Air Traffic Services Training Centre in Cornwall, Ontario, two of which are dedicated to the training of controllers for the Department of

National Defence. The remaining eight are dedicated to filling the new controller needs of the ATS Branch. Normal course loading is 24 students per course, for an annual intake of 192 students. However, at present, between 26 and 28 students are loaded on the Basic course which has increased the annual intake to 216 students. On 18 August 1989, the Minister of Transport announced the expansion of the annual intake to over 300 trainees commencing in 1990.

Since June 1987, just under 50 per cent of students who commenced basic training have successfully completed the course. Student attrition is particularly high in Segment 1 which is designed, in part, to be a continuation of the selection process.

Upon successful completion of basic training, students return to the region where they were recruited, and commence qualification training at their assigned unit. Specific duty assignments (ie., the unit and subunit where the trainee will be employed on completion of basic training) are normally determined prior to commencement of basic training by the regional Human Resources Coordination Committee. In each region, these committees are tasked with developing a Human Resources Plan which outlines the movement of personnel between organizations, attrition projections, growth requirements, and Training School seat requirements for each unit. At the present time, it is normally the requirements of the ACC that determine duty assignments of ab-initio students.

In the past, graduates of the Basic course were predominantly assigned to airport control duties. However, for a number of years, the demand for IFR controllers at ACCs has exceeded that for airport controllers. It has not been possible to attract a sufficient number of already licensed controllers, from either the airport control field or from other units within the IFR field, to satisfy this demand. As a result, there is now a significant need for controllers to enter the ACCs for IFR responsibilities directly from basic training. Ironically, duty assignments are made before basic training has commenced, without reference to the individuals' demonstrated aptitudes or abilities; i.e., individuals going to the ACCs may not be particularly strong in the IFR skills.

6.2.2 Qualification Training

Following completion of basic training, new entry controllers undergo qualification training at the region/unit level. Qualification training for any Area or Terminal Control Unit consists of a unit specific area or terminal control course followed by on-the-job training (OJT) in the operational unit. Courses are required for each specialty of each unit. During OJT, students practise on-the-job under the guidance and supervision of a qualified controller in order to adapt existing skills to unit conditions and to improve proficiency to the unit established performance standards[2]. In order to successfully complete qualification training at an IFR unit, a candidate must demonstrate proficiency to the required level in all sectors of the subunit to which he/she is assigned.

Qualification training for airport controllers also consists of OJT in an operational unit. This training enables the student to learn the local situation and practise on-the-job under the guidance and supervision of a qualified Airport/Aerodrome controller. As in the case of IFR units, to successfully complete qualification training at a control tower, a candidate must demonstrate proficiency to the required level in all positions in the tower. Control towers which are considered to require levels of skills and knowledge in excess of normal tower requirements are designated complex towers. Prior to undertaking OJT at a complex tower, students must successfully complete a complex tower course.

The duration of qualification training varies according to unit requirements. Typically, graduates of the basic course who are assigned to airport control duties at low/medium density control towers require five to six months of qualification training in order to achieve the required standard for unit check-out. Check-out at a complex tower requires significantly more time (eg. Toronto LBPIA requires up to one year or more). For direct-entry IFR candidates, qualification training requires approximately six months of advanced theory and site-specific simulation, followed by between 9 and 15 months of OJT.

Success rates in qualification training differ greatly between airport control towers and IFR units. At control towers, success rates are approximately 80 per cent; at IFR units success rates are about 20 per cent. However, there are significantly different success rates unit by unit and course by course.

6.3 AIR TRAFFIC CONTROL TRAINING FACILITIES

6.3.1 General

To accomplish required training, Transport Canada has established and equipped an Air Traffic Services Training Centre at Cornwall, Ontario and seven Regional Training Schools at Gander, Moncton, Montreal, Toronto, Winnipeg, Edmonton, and Vancouver. The Regional Training Schools are co-located with the seven ACCs. Basic training is conducted at the Training Centre at Cornwall, and the unit-specific course phase of qualification training is conducted at the regional schools.

6.3.2 Air Traffic Services Training Centre

Overall, the ATS Training Centre is modern, reasonably well-equipped facility for basic training. As in many training situations, the Training Centre employs a "synthetic" training environment. The airspace and airport employed in training situations and simulations are fictional. To a certain extent, control procedures and practices employed in the training situations are also "synthetic" in that in some cases, they differ from those in use in the "real world." In general, the use of this synthetic environment is based on sound reasoning. Graduates of the course disperse to a large number of units, so there is little to be gained by duplicating a specific "real" airspace segment or airport for training. Also, considerable flexibility is permitted by building an operating environment to suit particular training needs.

However, care must be taken when using this approach to ensure that realism is retained and the requirements of the client are met. Constant review of procedures and practices in use in the "real world" must take place, and, where necessary, revisions to training procedures and practices employed in training situations and the overall training environment must be implemented. Some senior controllers and managers believe that this review and revision is not taking place satisfactorily. They believe that there is a lack of realism in training at the Training Centre, and that students are learning information that has to be "unlearned" at the unit level. Contributing to this problem, in their view, are instructional staff who use their own interpretations of MANOPS to make the synthetic system work.

Senior ATS management does not share this view. Although they acknowledge the difficulties of using a synthetic environment, they believe that sufficient review and revision of course materials by operationally oriented staff does occur. Also, in their view, instructor turnover ensures a high degree of operational currency at the Centre. Clearly, finding a suitable balance between operational requirements and basic training needs poses a real challenge to those responsible for basic training.

6.3.3 Simulation

The Training Centre relies significantly on computer simulation to replicate the ATC environment and the equipment used by air traffic controllers in the field. Controllers-in-training complete about 150 simulation sessions during the three segments of basic training. Simulation capabilities range from a static trainer for the simulation of an airport control tower to a simulator for the training of future IFR controllers.

IFR simulation utilizes a DEC 10 computer (vintage 1974). This system is considered the forerunner to the JETS system in operational use at ACCs. However, although there is some commonality, there are differences in system usage. For example, the full radar data block is not available, nor are machine hand-offs of traffic permitted. Some instructional staff interviewed hold the view that the system should have been replaced several years ago, but that lack of funding has prevented its replacement.

The need for an improved simulator environment to increase controller training efficiency was recognized in the most recent Canadian Airspace Systems Plan (CASP) (1988):

> "Recent studies have shown that the cost per successful trainee is inordinately high. More effective training systems capable of accurately simulating the ATC environment have been identified as a means of reducing controller training costs."

Airport control simulation was also viewed as inadequate by some instructional staff interviewed. Simulation essentially provides a dynamic situation for practising standard phraseology. In addition, there is a confrontation simulator with audio-taped scenarios to develop the candidate's thought processes. Notwithstanding the above mentioned views, ATS management report that no requirement for improved VFR simulation has been identified. Furthermore, they do not believe that the technology exists for an acceptable degree of fidelity in simulating the VFR operating environment.

Simulators at Regional Training Schools have even less capability than those found at the Training Centre at Cornwall. These simulators are IFR in nature and are structured to represent the airspace associated with the local ACC. These simulators have not kept pace with the many technological advances of the ACCs and are now in need of a major overhaul. The 1988 CASP also recognizes the shortcomings of Regional Training School simulators:

> "Systems for air traffic control are in urgent need of improvement. Existing training systems at regional schools are not adequate."

To increase simulator capabilities within the ATC training system, the National Air Traffic Control Simulator (NATS) program was conceived. This plan calls for the revamping of the present system in order to provide the Air Traffic Services Centre and Regional Training Schools with a system capable of accurately simulating the evolving ATC operating environment. The goal of NATS is to provide the tools necessary to not only train novice controllers in a more realistic manner but also to permit periodic valid evaluation of controller proficiency. This approach is analogous to methods currently used for pilot training and proficiency checking.

Notwithstanding the long-term plans of the NATS program, instructional staff interviewed during the conduct of the field survey, including staff at the ATS Training Centre, were unanimous in their view that current ATC training simulation capabilities are lagging significantly behind present day technology. Transport Canada has invested and is continuing to invest heavily in modern, state-of-the-art automated systems for the control of air traffic. However, this investment has not been accompanied by a concurrent investment in equally modern training equipment. ATS management report that lack of non-operational resources have severely hampered the pursuit of technological advances in the area of simulation. This lack of investment contrasts unfavourably with increased emphasis on state-of-the-art simulation capabilities found in other segments of the aviation industry. Major airlines have long recognized the significant benefits of realistic simulation in the training of aircrew. Current simulation capabilities, which include high resolution visual displays, allow pilots to receive type endorsements on aircraft without ever having flown the specific aircraft type.

As an interim measure, ATS management report that current plans call for the installation of new IFR simulators at Regional Training Schools early in 1990.

High fidelity visual displays are now reportedly available for simulating control tower scenarios on large screens for airport operations anywhere in the world; e.g., VISRAD (a UK system) provides a 150-degree field of view on a 2 X 10 metre screen. One European simulator company has also recently unveiled a low-cost computer-based trainer for controllers. Named FIRST (Flexible Independent Radar Skills Trainer), it uses a microcomputer to simulate the ATC environment and its equipment. The company believes FIRST would reduce classroom training time and reduce OJT requirements by up to 30 per cent. Apparently, this radar trainer can be used for basic introduction through validation training. It also provides automatic reports on student performance to assist in teaching reviews.

There is unquestionably a role in ATC training for such high-fidelity mission or part-task simulators. They could be a valuable tool in teaching new procedures under increasingly high traffic levels and complexity. In addition, these simulators would be of significant benefit in the development and evaluation of new procedures.

There are other automated training aids currently in use in the aviation industry which have potential for application in ATC training. These aids, which include, for example, computer-based self-paced instruction, have done much to revolutionize training in aviation and other fields, and they permit significant gains in training effectiveness and efficiency. It does not appear that Transport Canada is capitalizing on the effectiveness of such computer-assisted learning - either at the Basic or Unit level.

In summary, although a field increasingly dominated by automation and advanced forms of computer assistance, this increased reliance on automation has not yet been adopted in the training of air traffic controllers. Early introduction of these new approaches and accelerated acquisition of new simulation capabilities offer significant potential for increased effectiveness and efficiency in the training of air traffic controllers.

6.3.4 Reporting Relationships

The ATS Training Centre does not come under the direct control of the ATS Branch. The Centre is one of several training units which comprise the Transport Canada Training Institute, which reports directly to the Director General Training (of Transport Canada's Personnel Group).

Although the ATS Branch exercises some functional control over the activities of the Training Centre, the consensus among those interviewed was that it would be a significant improvement if the ATS Training Centre came under the direct control of the ATS Branch. The view expressed was that, at present, the ATS Branch has good input into what training is conducted at the Training Centre but not how training is conducted. There was a general belief that the quality and relevance of training, and thus ultimately the success rate, would be significantly improved if

Basic training was placed under direct control of the user. This arrangement would facilitate better coordination between the trainers and the client.

Integration of the Training Centre into the ATS Branch would also permit more effective and efficient use of instructional staff. In periods where limited training is necessary, instructional staff could be quickly re-integrated into operational units and yet still be available to return to the school when demand increased.

6.3.5 Instructional Staff

Instructional staff at the Training Centre at Cornwall and at the Regional Schools are drawn from the ranks of controllers at operational units. In the case of instructors at Cornwall, controllers must compete for positions in accordance with the normal Public Service Commission competition process. Successful candidates receive a three and one half week instructor's course before commencing instructional duties.

There is a strong desire on the part of Training Centre management to recruit well-qualified and motivated instructional staff. However, there is stiff competition from operational units for the best people. As of July 1989, the Training Centre was operating with an instructor complement that was six lower than establishment. There is some feeling that the organizational separation between the Training Centre and the ATS Branch discourages some controllers from becoming instructors at the Training Centre. This is another argument in favour of changing the reporting relationship; recruitment of instructors might be facilitated as they would remain within the overall ATS structure.

For instructors to be effective, it is imperative that they maintain a good working knowledge of practices and procedures in use at operational units. To this end, a familiarization program for instructors has been established. Some instructional staff are of the view that the program should be longer to permit the instructors from the Training Centre to maintain a valid ATC license. Another approach suggested was the establishment of a program for the rotation of operational controllers through the School for three-year tours of instructional duty, thereby maintaining a high level of instructor currency and therefore training relevance. Such an approach would probably require integration of the Training Centre into the ATS Branch.

Regional Training Schools function as part of the ACC with which they are co-located. School operation is the responsibility of the Manager, Training and Human Resources. Instructional staff at Regional Schools comprises a combination of permanent instructional staff (normally one or two qualified controllers) and additional controllers seconded from the co-located ACC. In addition, there are other controllers who perform on-job-instruction (OJI) duties. They do so voluntarily, for which they receive an hourly pay supplement of $2.50. Some difficulty is being experienced in attracting controllers to become instructors, both in the regional schools and to a lessor extent, as OJIs in the Centres. To become an instructor in one of the regional schools normally means giving up the opportunity of significant amounts of overtime as an active controller in the ACC. Since student controllers operate on their OJI's licence, there is a commonly held view that the $2.50 per hour pay supplement is not worth the added responsibility to the OJI for "putting one's license on the line every day."

Clearly, an OJI assumes considerable responsibility when working with and monitoring a controller in training. OJT is the most critical stage in a new controller's development. As in any OJT environment, there is considerable discretion needed on the part of the OJI to maximize training value while at the same time minimize detrimental consequences to the operation at hand. This is particularly so in air traffic control, where the controller in training is actively controlling aircraft, and the consequence of error can be very high. When to intervene in a deteriorating control situation is not always an easy decision. The following loss of separation illustrates the problem facing OJIs.

> On 20 June 1989, a loss of separation occurred between a Boeing B-727 and a Douglas DC-10 in the vicinity of London, Ontario. The DC-10 was en route to Chicago from Montreal at FL390 and the B-727 was en route to Montreal from Chicago at FL370. Both aircraft were being controlled by a controller-in-training under the supervision of a qualified OJI. The loss of separation occurred when the controller-in-training issued descent and heading clearance to the DC-10 without ensuring separation from the B-727.
>
> An ATS Fact Finding Board concluded that the controller-in-training was experiencing difficulty controlling the traffic situation and was unaware of the confliction. Cause of the loss of separation was determined to be late intervention on the part of the OJI.

Attracting controllers to assume OJI responsibilities under such operating conditions is understandably difficult. Therefore, it may be necessary to offer further incentives to controllers to become on-the-job Instructors.

6.4 TRAINING OUTPUT VERSUS DEMAND

The Air Traffic Services National Staffing Plan projects the following "expected training output" for the years 1989 to 1996 inclusive:

Year	Output	Cumulative Output
1989	45	45
1990	77	122
1991	103	225
1992	103	328
1993	103	341
1994	103	534
1995	103	637
1996	103	740

Based on these projections and assuming additional external recruitment of 45 qualified controllers, Transport Canada predicts that not until 1994 will training be able to address the controller shortfall within the ATC system. However, even this prediction seems overly optimistic. It assumes no growth in controller requirements beyond 1992, and it is unclear how training output is to increase from 45 in 1989 to 103 in 1991 and beyond. In addition, recent experience with previously qualified controllers imported from the United States would indicate that estimates for external recruitment may be overly optimistic.

It is clear that the current staffing crisis within ATS is exacerbated by the inability of the ATS training system to provide sufficient new controllers to meet current demands of the operational units. The two principal elements to this problem appear to be the length of time it takes to train a new controller and the high attrition rates experienced during training.

6.5 LENGTH OF COURSE

At the present time, it takes between 15 and 30 months for an ab-initio controller to complete all phases of his/her training and fully qualify at his assigned position. Delays between recruitment and commencement of training can increase the time interval between selection of a candidate and commencement of controlling on an IFR sector, to more than three years. The field survey determined that it was a commonly held view that the present training stream is excessively long and that, to better meet the current high demand for new controllers, significant changes are required. Increased specialization is viewed as a rational approach to streamlining the training process. Transport Canada is exploring several initiatives in this area.

Current plans include shortening of the Basic course by streaming candidates to either IFR or VFR control training streams. Candidates destined for airport control positions would complete only the orientation phase and segments one and three of the Basic course; candidates destined for IFR positions in an ACC or TCU would complete the orientation phase and segments one and two. These changes will permit increasing the annual intake of the training system to 312, with a hoped-for corresponding increase in output. Current Transport Canada projections for training intake for the year 1990 and beyond use this higher intake figure.

Increasing the output of the ATS Training Centre could, however, seriously strain the OJT ability of operational units. To a large extent the bottle-neck in the training system is at the operational units. There is a limit to the number of trainees that can undergo OJT simultaneously. Therefore, it would not make sense to increase training output at the basic level unless there is the corresponding capacity to conduct the OJT phase of qualification training.

Other means of streamlining the process include a more developmental-type approach, akin to an apprenticeship program. This would include the streaming of candidates at TCTI and during qualification training. This type of specialization would permit controllers to qualify quickly on one or two sectors within a subunit, or one or two positions within a tower, as opposed to the current practice which requires check-out on all sectors/positions of a subunit. The current training approach is potentially wasteful in that it invests up to 30 months of training in an individual before confirming that the individual can actually perform a useful job. Transport Canada is in the process of exploring the feasibility of implementing an apprenticeship-oriented training approach. Supporters of this approach advocate a combination of a sector-specific course at the operational unit followed by on-job-training. Such an approach offers significant potential for reducing initial training time, thereby addressing the controller shortage problem in a more timely manner.

There are others who express great resistance to a more specialized approach. In support of this view, they argue that, at a time when the overall knowledge requirements of air traffic controllers is expanding, shortening the training period is counter-productive. There is concern that short-term training requirements are going to compromise the long-term educational base essential to creating a good air traffic controller cadre for the future. Some question when and how controllers will acquire the theoretical background that they will miss by not attending all segments of the Basic training syllabus. Others wonder what will happen to students who take specific segments but fail to qualify at their assigned position.

Although there are undoubtedly drawbacks and potential problems to an apprenticeship approach to controller training, as a short-term solution to the current crisis in staffing, it has merit and is worthy of serious consideration. Clearly, in view of the current crisis in air traffic controller staffing, new and innovative approaches to increasing the training system's ability to meet the demand of the operational units must be considered. Air Traffic Services' initiatives to explore the feasibility of apprenticeship/partial qualification training are encouraging. However, if implemented, such solutions must take into account long-term impacts. The long-term education and development needs of air traffic controllers must not be sacrificed in the interests of expediency. It is essential that any new approach incorporate programs to ensure the necessary educational base upon which a 20 to 25 year career as an air traffic controller can be built.

6.6 TRAINING ATTRITION

Attrition during the training process is the second significant element of the overall problem in providing sufficient new controllers to meet demand. To fulfil the demands for new controllers, intake at the front-end must greatly exceed required output. The high attrition rate currently being experienced is not new. There has been no significant change in this rate for at least 20 years, despite several initiatives to improve the success rate of candidates. It appears that Transport Canada's current primary response to the high attrition rate is to increase student intake, thereby increasing output. Although this approach will undoubtedly result in some increase in output, it addresses a symptom, and not what perhaps are underlying problems in the training system. A more effective and efficient approach would be a reduction in the attrition itself, assuming valid selection of controller candidates. Potential solutions could be found in a number of areas, some of which (partial qualification, revised section standards, streamlining of the training process) are now being actively pursued by the ATS Branch.

During the field survey, it was the opinion of several people whose primary responsibility was in the human resource field, that current recruiting and selection processes could be more effective. In their opinion, good candidates were unnecessarily screened out, and others, although selected, were lost to the system due to long delays between application and commencement of training (up to nine months in some cases). Because ATC is complex, it has never been easy to devise a selection procedure for controllers, and the attributes and characteristics of the successful controller are still being debated. Transport Canada is in the process of reviewing its selection criteria and screening processes for prospective air traffic controllers.

Current duty assignment practices do not take into account the strengths and weaknesses demonstrated by individual students during basic training; duty assignments are made prior to commencement of the basic training phase. There would appear to be potential for reducing post-basic training attrition rates by implementing changes to this practice. The differences in qualification training attrition rates between IFR units and airport control towers clearly demonstrate that for ab-initio controllers, direct-entry into IFR control is more difficult than check-out as an airport controller. For this reason, it would appear more efficient to assign students at or near the end of their basic training. Students could then be selected for duty assignments which best meet their demonstrated aptitudes and abilities. At the present time, students who demonstrate good aptitude and ability for IFR control may have already been pre-assigned to airport control positions. Conversely, students who demonstrate good aptitude and ability for airport control but whose chances for successful direct-entry IFR check-out may be below other students, may have already been pre-assigned to IFR duty positions. Better use of student strengths as demonstrated in the basic training phase offers the potential for significant reduction in student attrition during qualification training. However, ATS management caution that realization of this potential reduction would require a degree of precision in student evaluation that may not be possible to achieve.

The determination of duty assignments prior to the commencement of basic training may create another problem. Students who commence training are well aware of the high attrition rates for direct-entry IFR candidates. For those students that have been pre-selected to duty positions at IFR units, this can create considerable stress during training; stress that is not conducive to effective learning. This is particularly true for those students destined for high density IFR units with a track record of very high attrition rates (e.g., Toronto ACC). There is concern that the present system of pre-assignment creates a significant risk of self-fulfilling prophecy with respect to attrition rates for a significant segment of the students undergoing basic training.

Many of the personnel interviewed are of the view that the system expects too much of new controllers and that they need to be eased into the system more slowly. When one considers the complex nature of the tasks that controllers must perform, it is easy to see that the current training system expects much of its students in a relatively short period of time. Ab-initio candidates who are assigned positions at the busy ACCs are effectively thrust into active duty control at or near the top of the operating controller levels. There are few, if any, occupations outside of ATC which expect such rapid advancement. This practice is analogous to assigning a newly qualified commercial pilot to command of a Boeing 747. Undoubtedly, such demands contribute substantially to high attrition during qualification training. Perhaps, an apprenticeship approach to training would result in reduced attrition during training.

An apprenticeship approach would permit controllers to be trained in steps. Competency would increase gradually, and individuals would be permitted to build upon experience gained as an operational controller. Significant reductions in attrition would thereby result. Air Traffic Services' current initiatives to explore this new direction in training are to be encouraged.

It was the opinion of some instructional staff that the current training system puts too much emphasis on further selection, rather than on training of candidates. Furthermore, students in a class are expected to arrive at the same point of learning at the same time. There is no compensation for differences in learning rates and abilities. As a result, attrition rates are unnecessarily high. This uncertainty over the correct emphasis between selection and training of air traffic controllers is not unique to Canada. Some hold the view that good controllers are "born", not "made." In other words the main determinant of a successful controller is a pre-established set of aptitudes and abilities. Since these attributes are collectively rare, then high attrition rates in selection/training must be expected. The other point of view is that it is training which is essential, and that the controller is primarily a product of the knowledge acquired and of the ability to apply it. According to V. David Hopkins[3], "the evidence on this contentious issue suggests that selection is important but that air traffic control success may be more dependent on training." He further suggests that individual differences, rather than a nuisance, can be a potential advantage and that benefits might accrue if these differences were "taken more seriously during training and initial job allocation, as well as during subsequent career development when individual differences are once again widely acknowledged."

Until recently, controllers-in-training who failed to check-out upon completion of qualification training were released from the employ of Transport Canada. Although in the past this may have been an acceptable method to deal with candidates who were unable to qualify at their assigned positions, under the present circumstances it seems a waste of training time and what may yet be valuable human resources. Candidates who are unable to qualify at what are considered the more difficult units (e.g., direct-entry IFR at Toronto ACC) may well be able to qualify at less demanding positions. Furthermore, after several years of experience within the system, these same individuals may be more than capable of qualifying at the same unit where they had previously been unsuccessful. Under the past practice, they were forever lost to the ATC system; some, after a three-year investment of training. Recycling of unsuccessful candidates to less demanding units would seem to be a more effective and efficient use of all available resources. At the very least, some formal assessment of the capabilities of individuals should be undertaken to determine if they have potential for further employment in ATS. ATS management report that they are now attempting to re-assign controllers who fail to check out at IFR units to airport control duties.

6.7 POST LICENCE TRAINING

After air traffic controllers complete their preliminary and certification training and qualify to control air traffic, there are a few training programs that they are required to undergo throughout their careers and a large number of training programs that are optional, depending on the career choices made.

6.7.1 Refresher Training

All airport controllers and instrument controllers are required to undergo refresher training each year. The main objective of refresher training is to refamiliarize the operating controller with knowledge and techniques which were earlier learned either during original training or at some other point during the controller's working life. Often, subjects such as emergency procedures, application of IFR separation criteria, or radar vectoring and speed control techniques are covered in more detail than any other forum would permit.

Course content is partially dictated by the ATS Training and Human Resources Division in Ottawa, and partly by the Regional Manager of ATS. Normally, two to three days are dedicated to subject matter having a national implication with which standardization is considered vital and two to three days during which items of a purely local or regional nature are discussed.

At some locations, managers have asked professionals associated with the Air Traffic Control Occupational Health (ATCOH) program to give lectures on life management, stress, fatigue associated with workload and other related problems associated with a stressful working environment.

In recent years, there have been complaints from both management and staff centering on refresher training. Some managers are accused of using refresher course time to introduce new material and, in doing so, are stealing valuable time otherwise used to refamiliarize personnel on material with which they may well be "rusty."

There was a consensus among those interviewed during the field survey that staff shortages over the last several years have meant that many controllers have not received a full five days of refresher training. This problem is so critical at some locations that unit managers have not been able to approve five days - even on overtime! At the locations visited, most managers have only been able to approve an average of two to three days a year, and all refresher training is now done on an overtime basis. Throughout the system, the shortage of staff has resulted in individuals on course being recalled for immediate duty on the operations floor.

Some controllers have complained that some of the subject matter selected for refresher training is not valid. Managers at the sites visited feel strongly that they are doing their utmost in a very difficult situation. Until staff levels reach a more reasonable level, the problems with refresher training are likely to remain.

6.7.2 On-The-JobInstructor Training

Over the course of one's career, qualified controllers may provide instruction to trainees undergoing qualification training on-the-job. To perform these special duties, management requires that these controllers be equipped with the pedagogical skills necessary to help the trainees to attain their maximum potential.

To this end, OJI seminars are organized and presented. However, as with refresher training, OJI courses have been very difficult to schedule due to the shortage of staff.

OJT training is the most critical stage in a trainee's qualification training. At most locations, tower or ACC, it requires many months to acquire the working knowledge necessary and the confidence to permit an individual to assume the role of a qualified controller.

It is during this phase that the majority of candidates judged unsuitable are eliminated; at some IFR sectors, the rate of attrition can be as high as 90 per cent. For many years, ATS management has attempted to lower the attrition with limited success. OJI seminars were introduced as a method of improving the level of instruction, thereby of reducing the very high attrition level.

6.7.3 Update Training

As complicated changes to sector configuration and airspace become more frequent, there is an ever-increasing need for update training. This training most often occurs in a simulated environment and, depending on the scale of the project, may last between one day and several days. For detailed projects, training may be carried out at the Simulation and Experimentation Centre in Hull, Quebec.

6.7.4 Supervisory Training

Line controllers promoted to the first-line supervisory level should pursue courses intended to better equip them with the necessary human relations and management skills. However, the ATS Branch has not developed a specific "supervisors course." More often than not, operational controllers advance to supervisory positions without any specific training in how to be an effective supervisor - in part due to their limited availability for training during staff shortages.

As in many other occupational fields, the decision to upgrade an individual to the supervisory level is largely based on their performance at the working level. Inherent in this practice is the assumption that a good controller will make a good supervisor of controllers. In many cases, this is a valid assumption. Clearly, to be an effective supervisor one must possess the requisite skills and aptitudes to perform the job of subordinates. However, equally important is the need to possess the knowledge, skills, and aptitudes necessary to effectively motivate and lead subordinate staff.

Air traffic control is a team activity. The success of any team activity is to a large extent dependent on the effectiveness of team leadership. This team leadership is provided by the supervisor. Given the importance of the supervisory function, supervisors require specific training and development to prepare them for the leadership and management role expected of them.

6.8 OBSERVATIONS

1. The current staffing crisis within the ATS Branch is exacerbated by the inability of the ATS training system to meet current demand for qualified air traffic controllers.

2. Current Transport Canada projections indicate that training will not redress the controller shortfall until at least 1994; these projections may be overly optimistic.

3. The length of time it takes to train an ab-initio controller and the high levels of attrition experienced during training contribute significantly to the inability of the training system to meet the present demand.

4. Over the past years, there has been a steady increase in the requirement for direct-entry IFR candidates at ACCs.

5. Attrition rates among direct-entry IFR candidates are substantially higher than those for new controllers who initially assume VFR control positions.

6. Transport Canada practices which resulted in the release from employment of those candidates who failed to qualify at their assigned operational IFR unit did not take into account the possibility that these candidates may have been well-suited for employment elsewhere in the ATS system.

7. In order to qualify at an operational unit, new controller candidates must demonstrate proficiency in all positions of the subunit to which they have been assigned.

8. Duty assignments for new air traffic controllers are decided prior to commencement of basic training. This practice does not enable ATS management, when making assingments, to take into account individual student strengths and weaknesses as

demonstrated in basic training, thus resulting in unnecessary wastage of talent.

9. Transport Canada's current ATC training system expects a high level of performance from ab-initio students. In many cases new controllers are assigned to operational positions at or near the top of operating controller levels. This practice is analogous to assigning a newly qualified commercial pilot to command of a large transport-category aircraft.

10. Maintaining a balance between real-world operational requirements and synthetic training needs poses a continuing problem for ATC trainers.

11. Current Transport Canada actions to increase the output of the training system rely almost exclusively on increasing student controller enrolment. However, new initiatives to reduce controller training attrition and to reduce the time taken to train a qualified controller are now under consideration. Current Transport Canada initiatives to re-evaluate and revise current selection standards, increase emphasis on training as opposed to selection in the training process, consider partial qualification for new controllers, and to adopt an apprenticeship-type training approach must continue.

12. Transport Canada is experiencing difficulties in attracting a sufficient number of qualified candidates for instructional positions at its Air Traffic Control Training Centre and for OJI positions in operational units. New incentives may be required to attract the most suitable personnel to the vital training function.

13. The use of simulation in ATC training is lagging significantly behind current technology and contrasts unfavourably with the increased emphasis on simulation as an effective training tool found in other segments of the aviation industry.

14. Increased reliance on state-of-the-art simulation capabilities and computer-assisted learning offer significant potential for increasing the effectiveness and efficiency of air traffic controller training - both at the basic and the refresher levels.

15. Many controllers are not receiving the required refresher training necessary for the maintenance of the skills and knowledge essential for meeting all operating contingencies safely.

16. The current reporting lines in Transport Canada for Basic controller training compromise the operational currency and relevancy of training; greater balance is required between operational and training needs.

LIST OF REFERENCES

1. Transport Canada, Aviation Group, "Basic Controller Training", TP 1926E, September 1983.

2. Transport Canada, Aviation Group, "Qualification Controller Training", TP 1946E, January 1989.

3. Hopkins, V. David, Human Factors in Air Traffic Control, AGARDograph, N. 275, 1982.

CHAPTER 7

SUPERVISION

7 INTRODUCTION

Quality control in ATC is an important element of maintaining system safety. Responsibility for assuring quality control is spread throughout the hierarchy of the ATS Branch. At the Headquarters level, a variety of specialists and managers are assigned duties that relate directly to quality control. These individuals are involved in the allocation of resources, the development and publication of standards, operating practices and procedures, or through unit evaluations, the assurance of correct and consistent application of standards and procedures. At the unit level, individual controllers, supervisors, shift managers, and senior unit management all play a part in ensuring the quality of day-to-day operations within the unit.

However, it is the first-line supervisors who are principally responsible for assuring the day-to-day quality, and hence safety, of the ATC service provided by their subunits. Supervisors are responsible for overseeing the activities of controllers within a subunit, balancing workload, providing briefings on new procedures or for the maintenance of operating standards, and administering various quality control programs. In short, first-line supervisors set the operational tone which determines the effectiveness of their team of controllers.

7.1 ROLE OF THE SUPERVISOR

The role of the first-line supervisor has undergone significant change in the past several years. Prior to 1983, management and administrative functions were increasingly emphasized over active control of air traffic. As a result of this increasing emphasis on non-control duties, many supervisors had lost their qualifications to assume active control responsibilities. This was accompanied by a gradual erosion in the credibility of first-line supervisors among fellow controllers. Although it had been their role to manage a subunit, lacking the practical experience in an ever more complex environment made it increasingly difficult for them to take an active part in the activities of the subunit; in many cases their involvement had become limited to assigning meal breaks and rest periods.

In 1983, a reorganization was implemented at ACCs which substantially altered the role and responsibilities of the first-level supervisor. This reorganization saw the introduction of a shift manager into ACCs. Designated as "management's representative" on the operations floor, the shift manager assumed many of the management-related duties previously the responsibility of the supervisor. Relieved of their administrative functions, supervisors were free to take on a team leader role within the subunit. This new role included active control of air traffic. Qualified and at ease with control duties, the new supervisors would directly observe and supervise the controllers within their subunits.

The re-integration of the first-line supervisor into the operational complement of controllers at ACCs was to be based on the "last in - first out" principle. In other words, supervisors were to assume active control positions as traffic levels increased on a given shift, and additional sectors were opened. Conversely, when traffic levels decreased and sectors were consolidated, supervisors were to be the first to be removed from active control positions. It was envisaged that supervisors would spend about 50 per cent of their duty time in active control positions.

The new role requires that supervisors possess a thorough knowledge of the technical aspects of control within the subunit. Since it was envisioned that up to 50 per cent of a supervisor's time would be spent at an operating position, supervisors are required to be fully qualified at all control positions within the subunit.

The supervisor is responsible for managing the traffic flow and must have the experience that will permit him/her to evaluate the workload of the subunit and to open and close sectors accordingly. As the traffic flow builds, a supervisor, who is free of an operating position, is able to act as a coordinator, thus relieving the difficulties in communications that develop between subunits during particularly busy sessions.

The first-line supervisor plays an important role in briefing employees on new procedures, reconfigurations of airspace, and sectorizations. Although they may not always be involved with a briefing presented by a shift manager or other area specialist, it rests incumbent on the supervisors to research and respond to further questions that invariably come up for discussion at the sector level. The supervisor must be well enough informed on new procedures to explain the background and history of changes when this is required.

Supervisors are often called on to provide interpretations when there are questions on the application of procedures. Whether the subject be a local procedure or a MANOPS interpretation, it is largely the first-line supervisor who provides answers to controller's queries, either through personal knowledge or after consultation with a higher authority.

Frequently, due to long experience, the supervisor is deeply involved in sector project work. Major or minor studies are underway continually in nearly every subunit in Canada. It is the nature of the work in general and the disposition of controllers in particular that results in an almost never-ending refinement of procedures and techniques.

First-line supervisors have a role to play in all training done at the sector level. While always involved in the on-the-job training being conducted in the subunit, the first-line supervisor is as well often called upon to develop and conduct the refresher training for the subunit.

The supervisor is also responsible to evaluate individual employees within his/her subunit. Using programs such as the Phraseology Improvement Program (PIP) and the Knowledge Verification Test (KVT), a supervisor must prepare a Proficiency Review and Assessment of Potential (PRAP) on each employee once a year. In a normal subunit configuration, a supervisor might be responsible for as many as six to eight employees on a particular shift.

Whether it be a question of discipline, the counselling of an employee experiencing a personal problem or the discussing of a shift change, the supervisor is called upon many times a day to carry out functions not directly related to the control of aircraft. Supervisors are also required to meet regularly among themselves and with shift managers and other unit managers to discuss the ongoing objectives and strategy of the ACC.

7.2 PROBLEM AREAS

The change of role for first-line supervisors implemented in 1983 was based on sound reasoning. However, as a result of the chronic staff shortages within the ATS system, it is a commonly held view that first-line supervision throughout the system has been seriously compromised. There was overwhelming consensus among those interviewed during the field survey phase of this investigation that first-line supervision at many units is, at best inadequate, and at worst, is non-existent.

This perceived problem of inadequate supervision is closely linked by operations personnel to the staffing shortages currently being experienced at most operational units. Where staffing shortages are the most acute, so is the problem of inadequate supervision. Controllers, supervisors, and managers all agree that the first-line supervisor of today has little hope of performing his/her supervision functions in any meaningful way. At many locations, the supervisor has become a higher paid controller!

It was a commonly held view among those interviewed during the field survey phase of the investigation that supervisors were spending 85 per cent to 90 per cent of their time at a control position within the subunit. As a result, supervisors were unable to perform the traffic management, workload balancing and overseeing functions. Ironically, it is during high traffic periods when supervision is most needed, that supervisors are least available to provide the supervisory function.

At present, management's real representative on the floor of an ACC is the shift manager. While shift managers are former operational air traffic controllers, by and large they do not maintain their licences (and therefore their currency) as air traffic controllers. Depending upon how long they have been away from active control duties, some of them have a very limited capability to provide operational assistance to first-line supervisors needing relief. Hence, many line controllers spoke rather contemptuously of the shift manager's role; they perceive it as being a "babysitter", "den mother", "super clerk", etc. They do not perceive the shift manager as a source of managerial guidance regarding operations. On the contrary, one supervisor pointed out that he would implement flow control if and when he saw fit, regardless of the shift manager's advice, because it was his (the supervisor's) licence that was on the line.

During the field survey phase, there was clear consensus that the lack of supervision was contributing to system errors. This consensus was supported by the file review of 217 loss of separation incidents. In that review, although analysts established no direct link between the occurrence and the fact the supervisor was working a sector, the supervisor was found to be working an active control position at the time of the occurrence in 72 cases and was therefore not available to "supervise." Such supervisory related occurrences were more prevalent at Toronto (13 per cent) than at Gander (5 per cent).

Notwithstanding the consensus found during the field survey phase of the investigation, ATS Headquarters management are of the opinion that excessive supervisor "on sector time" is, for the most part, "elective" and not a system requirement. They agree that since re-integration of supervisors into the operational controller complement, it has been a common perception that supervisors must work up to 90 per cent of their time on a sector. However, they argue that this perception is not supported by fact. During the period February 1987 to April 1987, a review of IFR operational units was conducted to examine the utilization of supervisors in ACCs. The results of this review were published in a report entitled "Utilization of IFR Supervisors, Area Control Centres." The review determined that controllers and supervisors had, on the average, three hours away from a control position during each shift. It was concluded that if indeed a supervisor was working at a control position 90 per cent of the time, it was by choice, rather than by necessity. The study found that if the supervisor had utilized the available controller staff in a more appropriate manner, he/she would have been able to spend more time performing supervisory functions. ATS management acknowledge that staff shortages are more critical today than in 1987; however, they state that, without supporting data, the views of field personnel that 85 per cent to 90 per cent of supervisors' time must be spent actively controlling aircraft are subjective only.

7.2.1 Operational Overview

The file review found that, in many cases, the lack of supervision may have meant that an error or errors on the part of one or more controllers was not detected before a loss of separation occurred. Had adequate supervision been in place, it is probable that some of these errors would have been detected before the loss of separation occurred. For example, in the following case, it is possible that operational overview on the part of a supervisor may have detected and corrected the deficiencies in the controller's work habits.

> On 24 December 1987, a loss of separation occurred between a Boeing 737 and a de Havilland DHC-7 approximately 25 miles east of Vancouver. Both aircraft were receiving vectors for an approach to land at Vancouver; the B-737 was north-westbound and the DHC-7 southbound. The aircraft passed each other with less than the required lateral separation at about the same altitude.
>
> An ATS Fact Finding Board determined that the loss of separation was caused by the Arrival controller's delay in recognizing a conflict which had been created while sequencing the B-737 ahead of the DHC-7. Contributing to the occurrence were poor vectoring techniques, questionable control decisions and other deficiencies in work practices on the part of the controller.

> The Fact Finding Board determined that in a 15 minute period during which the loss of separation occurred, the controller committed 64 procedural or phraseology errors.
>
> At the time of the occurrence, no team supervisor was on duty.

Problems in inadequate supervision exist in the area of airport control as well. The following example illustrates how inadequate supervision may have contributed to a near collision involving two aircraft under airport control.

> On 15 November 1988, a near collision occurred between a British Aerospace Jetstream 31 and a Canadair Challenger at Toronto LBPIA. The Jetstream had been cleared for take-off on runway 24R only seconds after the Challenger was cleared to cross the runway the "Romeo" taxiway. A collision was avoided when the Jetstream pilot refused the clearance because he could see the Challenger crossing the runway ahead.
>
> The CASB investigation into the occurrence found that the North Tower controller had cleared the Jetstream for take-off after having forgotten he had previously approved the North Ground controller's request for the Challenger to cross the active runway.
>
> At the time of the occurrence the tower supervisor was working an operational position and could not perform active supervisory duties. Thus, he was no in position to detect the error.

During periods of intense work activity, momentary lapses in judgement or memory are natural. Furthermore, during peak periods, there is a need to respond to unexpected contingencies with an effective and coordinated plan; such a coordinated plan may not be possible from a person charged with the responsibility for controlling all aircraft in one sector. Lapses in judgement or memory which go unnoticed or unchecked, combined with an inability to coordinate a response to the unexpected, can have serious accident potential. Although it would be impossible for supervisors to detect and correct all controller errors, working supervisors are unable to maintain an effective operational overview by monitoring the activities of controllers within their subunit.

The results of the file review and field survey confirmed CASB concerns regarding supervision and operational overview which arose as a result of a near collision between a Boeing 737 and an Airbus A310 at Toronto LBPIA on 06 November 1988. That occurrence was determined to be the result of a classic chain of events, none of which in themselves constituted a serious error or departure from established procedures. At any one of eight or nine stages in the evolution of events, someone could have intervened to break the occurrence sequence. At least seven professionally competent personnel, both in the tower and the terminal specialty of the ACC, contributed to the chain of events. Yet, no one had a sufficiently broad perspective or operational overview of the situation to initiate remedial intervention. On the night of the occurrence, staffing in both the tower and the terminal specialty was normal. The tower was manned by five controllers and two assistants, and the terminal specialty was manned by five controllers, one of whom was designated as the coordinator. In the tower, the designated supervisor was working the North Ground position, and in the terminal, the designated supervisor was working the busy South Departure sector.

As a result of this occurrence, the CASB recommended that:

> The Department of Transport take immediate steps to ensure that designated controllers are maintaining an operational overview of the evolving air and ground traffic situation in each of the Toronto ATS units during busy traffic periods. (CASB 88-18)

The Department of Transport has responded favourably to this recommendation by increasing the supervisory complement at the Toronto ACC to permit dual supervisory coverage in all specialties during an eight-hour period when traffic is heavy. In addition, notwithstanding ATS management's view that excessive supervisor "on sector time" is, for the most part, "elective" and not a system requirement, Transport Canada is developing an operational plan to increase supervisory complements, thereby providing an operational overview capability during high traffic periods within all ACCs and major towers. This plan will provide the supervisory capacity to perform operational overviews on a daily basis during one or more operational shifts by adjusting the number of team supervisors in each ACC, and reducing the requirement to perform control duties on a systematic basis. Implementation of this plan will increase the system-wide supervisory establishment by 46 PYs.

Notwithstanding this increase in supervisory establishments, increased supervisory capability will not occur until suitably qualified controllers are available. Given the length of time it takes to train a new controller and the difficulties experienced in attracting qualified controllers to some units, a real increase in the number of supervisory staff may be some distance away.

7.2.2 Workload Distribution

The concerns of controllers and supervisors regarding the current level of supervision extend beyond the current inability of supervisors to detect operational errors on the part of controllers within the subunit. Workload distribution, through the opening and closing of sectors, is an important element of the supervisor's responsibilities. The practice of supervisors working sectors up to 90 per cent of the time seriously compromises the supervisor's ability to perform this function. As a result, many controllers and supervisors believe that effective and efficient workload management is not occurring. Originally required to spend approximately 50 per cent of their time doing control activities, supervisors report that often they now find themselves trapped at an operating position, frequently a very busy position, for virtually their whole shift. Unable to step back and assess the subunit's needs for breaks and rest periods, they are unable to effect systematic and pragmatic allocation of the available resources. Sectors are being combined by controllers themselves with no real authority, and, once closed, supervisors, still trapped in an operating position are unable to patrol the subunit and recall controllers when the traffic starts to build. The following remark is representative of the views of the majority of controllers and supervisors interviewed during this investigation: "There is no criteria for opening or closing sectors. Supervisors responsible for workload distribution are working sectors." (Issues related to the opening and closing of sectors are also addressed in Chapter 8, Procedures and Chapter 10, Information Transfer.)

The file review found several instances which illustrate the problem of lack of supervision as it relates to workload distribution. For example:

> On 03 September 1987 a loss of separation occurred between a Boeing 747 and a Lockheed 1011 operating in high-level airspace over northern Saskatchewan. The Boeing 747 was en route to New York from Anchorage, and the Lockheed 1011 was en route to Calgary from Frankfurt. Both aircraft were operating at FL370. The loss of separation occurred when the two aircraft crossed tracks with only two minutes spacing at the crossing point, vice the required 15 minute separation.
>
> The Fact Finding Board held following the occurrence determined that the primary cause of the loss of separation was the failure of the responsible controller to check the entire route of the Boeing 747

for conflictions prior to issuing a clearance for the aircraft to climb to FL370.

At the time of the occurrence, traffic within the applicable sector was assessed as heavy and very complex. The controller had become involved in an unrelated aircraft emergency approximately 20 minutes before the Boeing 747 was cleared to FL370. As a result of the workload level, the controller was unable to keep up with data board functions to the point that he was unable to maintain a complete picture of traffic within his sector. The data and radio sectors were combined at the time; Pace Level was assessed to be 6 or greater.

At the time of the occurrence, the supervisor was working a control position. The Fact Finding Board found that, had the supervisor taken action to divert radio reports regarding the emergency situation, the workload could have been reduced to a more manageable level.

7.2.3 Controller Discipline and Deportment

As previously stated, it is the first-line supervisor who sets the operational tone within a subunit, including individual controller deportment and discipline. Teamwork is a key to effective and safe ATC operations. It is the first-line supervisor who is tasked with leading the team.

In general, controllers exercise a high level of professionalism toward their work. However, occasional lapses do occur. For example, controllers working in proximity will, during periods of low workload, frequently engage in casual conversation. Such conversation, if not monitored by the supervisor, can present a distraction and result in a lack of attention to control duties. Inattention has been identified as a principal contributing factor or cause in many loss of separation occurrences. (The file review of 217 occurrences assigned inattention, forgetfulness, or distraction in 129 occurrences!)

Individual controller discipline in the use of equipment, in adherence to operational standards, and in general deportment all require some level of supervisory monitoring. If left unattended, lapses can result in a general deterioration in discipline and encourage wide-spread contravention of existing rules and good operating practices. A few controllers interviewed spoke of a general decline in personal discipline at work stations; e.g., feet up on consoles during quiet periods. Further, as indicated in Chapter 10, Information Transfer, Fact Finding Boards consistently report numerous deviations from prescribed phraseology reflecting a sloppiness which could eventually contribute to a breakdown in effective communications. Other controllers spoke of cutting corners and even "cheating" with respect to separation criteria in order to expedite the flow of traffic. The cumulative effect of such minor breaches in professional discipline can significantly contribute to the potential for a serious occurrence.

While the supervisor is supposed to set the professional tone for his team, as already pointed out, this is extremely difficult when he is locked into an operating position. Furthermore, since his role has essentially become that of just another controller, supervisors tend to think of themselves as just one of the guys. This makes is extremely difficult for them personally to exercise their responsibility among their peers with respect to the maintenance of high professional standards of discipline.

At busy sectors, at which controllers are required to spend long hours, there is occasional edginess and sharp words. A well placed supervisor can deflect problems of this nature before they result in strains on the working relationships in the subunit team.

7.3 SUPERVISORY STAFFING

Although Transport Canada has recognized the need for more supervision and is currently developing plans to increase supervisory complements at selected units, it will be some time before the actual number of supervisors available increases. Any increase in the number of supervisors will only be effective if it is accompanied by an overall increase in the number of qualified controllers. As discussed in Chapter 5 Staffing and Workload, such increases are some time away.

The situation is exacerbated by the fact that many working controllers are not interested in becoming supervisors. They question the wisdom of taking on additional responsibilities for little or no personal advantage. While supervisors in some units are not required to hold the midnight shift, the financial rewards of advancing to a supervisory level from line controller are minimal. At ACCs for example, the difference in annual salary between a line-controller and a first-line supervisor is just under $2,000. In addition, as supervisors, many feel that there is less opportunity to work overtime. As a result, many controllers felt that there is a financial penalty involved in rising to the supervisory level.

As well, there were many who felt that, in the current circumstances, supervisors have an unusually heavy workload with the associated responsibilities, are often placed in positions where their licence is "on the line", and yet, receive little support from management or the working controllers. In some cases, controllers who previously occupied supervisory positions have given up those positions and gone back to duties as journeyman controllers. In Montreal ACC, six supervisors have recently left the supervisory ranks. To a greater or lesser degree, this problem exists at most units. Given such examples of "downward mobility", it is not unusual that working controllers resist taking on supervisory responsibilities. For example, one Montreal controller wondered aloud why any controller would "climb the ladder" to the supervisory level when faced with so many supervisors trying to "scramble down."

7.4 QUALITY CONTROL PROGRAMS

Concerns over the effects of inadequate supervision also extended into the area of the conduct of quality control programs. To help identify weaknesses in the performance of individual controllers, several quality programs are conducted at the unit level. These programs are normally conducted annually.

ATC phraseology is a specialized, pragmatic syntax used by controllers and pilots to communicate in a manner so as to eliminate, to the greatest possible extent, any misunderstanding or miscommunication. The actual words employed, the sequencing of the message, and the timing of the message are all critical to its understanding. Imprecise directions such as "right at the next available" (versus "exit at taxiway Charlie") can easily be misinterpreted, particularly for flight crews unfamiliar with local operating procedures.

The Phraseology Improvement Program (PIP) is a quality control program that requires supervisors to audit ATC tapes taken while a controller was on duty for the purpose of evaluating and where necessary, correcting sub-standard phraseology. The field survey revealed that most controllers accept the Phraseology Improvement Program to be necessary for the maintenance of professional standards.

"Over the shoulder" evaluation, as they have come to be known are also to be done once a year. During a normal work session, supervisors are required to monitor the performance of their controllers in routine functions. Faults in the application of procedures, in coordination, or in phraseology are noted, and, at the termination of the evaluation, the controller is interviewed and feedback is provided on his performance.

A written Knowledge Verification Test (KVT) is required to be completed twice a year during which controllers are tested on their knowledge of the procedures and criteria. While supervisors and managers recognize the need for knowledge verification, adverse feedback was received with respect to the adequacy of the existing programs. Standard questions are repeated year after year without update, thereby compromising the long-term effectiveness of the test. Some managers expressed concern as to whether the KVT was a realistic assessment of a controller's actual job knowledge; indeed, a couple of managers expressed concern that many controllers would fail a comprehensive, no-notice, closed-book written examination of their knowledge.

With very few exceptions, controllers, supervisors and managers alike confirmed that at most locations, quality control programs are not being conducted in any consistent manner; at some subunits they are not being conducted at all. An overwhelming number of those interviewed during the field survey phase of the investigation attributed this to the lack of time available to supervisors for the purpose of performing supervisory functions.

7.5 OBSERVATIONS

1. There is a serious lack of first-line supervision in the ATC System today.

2. Although there is disagreement between ATS management and operations personnel over the underlying factors which have caused the problem and the exact percentage of time supervisors' "on sector time", first-line supervisors are now working active control positions for periods of time far in excess of that originally envisaged when supervisors were first re-integrated into the operational control complement.

3. The supervisor was found to be working a control position in 72 of 217 (or 33 per cent of) loss of separation cases examined in the file review phase of this investigation.

4. During high traffic periods, when supervisors are most needed, they are least available.

5. The ability to provide an effective operational overview and hence ensure quality control in operations is compromised by the lack of supervisors.

6. There are inadequate incentives to attract and retain appropriate personnel in first-line supervisory positions.

7. The effectiveness of established quality control programs has been compromised by the shortage of first-line supervisors.

8. Although Transport Canada has developed a plan to increase supervisory complements at all ACCs, a real increase in the supervisory complement will require additional controllers, not just an increase in PY allocation.

CHAPTER 8

OPERATING PROCEDURES

8.1 GENERAL

8.1.1 Need For Standard Operating Procedures

ATC is governed by procedures. Whether by rule, criteria, or common practice, almost every task performed in an ATC unit has been examined, and standard operating procedures have been specified. There are standard procedures and phraseology for communications and for processing information. There are standardized separation criteria which must be adhered to, both for operations with radar and for control of aircraft in a non-radar environment. Airport towers have procedures for handling VFR aircraft in the control zones, and IFR facilities have another set of procedures for controlling aircraft under instrument flight conditions. In addition, there are procedures for coping with in-flight emergencies. Independent action and creativity are not desirable, since controllers must work in tightly knit teams, each member depending on their counter-parts to follow the standard procedures.

The need for team work has been tested severely during recent years, given the increased traffic volumes and continuing staff shortages. Trapped by circumstances, managers struggle to replace missing controllers with others on overtime. As one controller in Toronto stated, "You never know who you'll be working with until you arrive!" This situation has made it even more vital that standard procedures be followed.

Furthermore, the 183 ATS units in Canada must be able to interface effectively with each other to ensure a coherent Canadian ATS system. Standard operating procedures facilitate this operational interface between operational units. Many of these units must also be able to interface effectively with adjacent control units operated by other countries; e.g,. the United States, the United Kingdom, and Iceland.

Only when procedures are developed and applied in a standardized manner does the ATS system work well. Of the 362 Transport Canada Fact Finding Board reports mentioned in Table 3-1, Transport Canada investigators assigned procedures-related cause factors 33 times.

Inadequate procedures	18
Ambiguously worded procedures	4
Too complex procedures	1
Procedures not provided	2
Responsibilities not clearly defined	5
Other procedures	3
Total	33

On the other hand, of the 217 occurrences files reviewed in detail by CASB's special investigators, procedures-related problems were noted in 52 files. In other words, nearly one quarter of the occurrences may have procedural shortcomings. This chapter will discuss and observe on many of those shortcomings.

8.1.2 Procedures Development

Procedures are developed at three different levels of the ATS organization: national, regional, and local.

a) At the national level, air traffic procedures are analysed from a system-wide perspective. Generally, rules and criteria established in Ottawa are for national application. However, on occasion, controllers in Transport Canada Headquarters will provide assistance in the development of region-specific or site-specific procedures.

b) Up until 1987, specialists in Transport Canada's Regional Offices participated in the development of procedures for the Regions and assisted Regional ATC units in their understanding and application of national procedures. However, since April 1988, all major Air Traffic Control units in Canada come under the management of the IFR Operations Division in Ottawa, This change resulted in considerable streamlining of several administrative functions while providing centralized management of IFR units. The goal of this reorganization is to achieve a more rapid response to national operational needs and a greater uniformity of application of senior management decisions. At those airport control towers, not in the IFR Operations Division, Regional Offices sometimes help with procedural problems.

c) In ACCs, TCUs, and airports in the IFR Operations Division, operational specialists analyse local operating conditions and recommend procedural changes where necessary.

ATC procedures are developed in response to a need or to a change in the environment in which aircraft operate. They may be conceived at any level of the organization and often answer changes in the industry or factors affecting aviation safety. Some examples follow. Improved aircraft navigational capabilities now permit long distance direct point-to-point navigation (e.g., from Toronto to Vancouver); ATC procedures were amended accordingly so that appropriately equipped aircraft need not follow the established airway structure. Since the introduction of economic regulatory reform, a de facto hub and spoke system of air traffic in Canada has evolved, analogous to that in the United States. These changing traffic patterns have necessitated a restructuring of the ATC sectors within the centres to accommodate the changed traffic patterns. Standard Instrument Departures (SIDs) and Standard Arrival Routes (STARs) have been prescribed to expedite traffic in the vicinity of major terminal areas, while minimizing cause for noise complaints from local citizens. Procedures have been developed to reduce flight times and hence fuel consumption by commercial carriers. Procedures for coordination of information have been streamlined to reduce controller workload and the human errors frequently associated with information transfer.

Following an aviation occurrence, a Transport Canada Fact Finding Board or a CASB Investigation may identify system deficiencies requiring amendment of procedures. For example, there have been several occurrences at LBPIA when parallel instrument landing system (ILS) approaches were in effect:

> On 10 January 1989, a McDonnell Douglas DC-9 was established on final approach for runway 24 Left and was cleared for the approach. A British Aerospace BA31 Jetstream was being vectored for runway 24 Right. The Jetstream was not given a final turn to intercept the localizer and at proceeded through the on course such that the two aircraft passed with 400 feet vertical spacing and 3/4 of a mile horizontal spacing.
>
> Some three hours later, a Boeing 737 was established on final for runway 24 Left at LBPIA and was cleared for the approach. A Boeing 767, was on a right base on a heading of 190 degrees for runway 24 Right, descending to 3,000 feet. Although the B767 was instructed to turn right to intercept the localizer, apparently a computer problem on the aircraft prevented the autopilot from acquiring the localizer. However, even if the autopilot had functioned normally, the required spacing between the two aircraft would not have existed.

Because these aircraft were being vectored for parallel ILS approaches without vertical separation, the CASB recommended that:

> The Department of Transport institute changes which will ensure adequate vertical spacing between aircraft being vectored for parallel ILS approaches at LBPIA.
> (CASB 89-02)

Subsequent to this occurrence, Transport Canada insisted upon a more rigid application of the vertical separation procedures prescribed in ATC MANOPS.
changes.

It is generally through the investigation of occurrences that managers of the ATS system are able to pinpoint weak areas. To prevent recurrence, managers are quick to seek procedural change. Indeed, during the field survey, feedback was received that perhaps management was too quick to institute change. As one controller stated: "They change procedures instead of accepting the fact that the procedures were alright, but the controller was to blame." Another stated: "Many procedural changes were made as a result of a Fact Finding Board where there was nothing wrong with the procedure and the incident was directly attributable to a human error." Certainly there is a fine line between change-for-change sake and the need for developing procedures which are more resistant to human error.

Many changes to procedures develop from the operational side of the organization. In the normal conduct of their duties, controllers, supervisors, or other members of the unit staff identify needs for procedural correction or enhancement. Controllers also frequently conceive better methods of performing their work.

When procedural change is required, depending upon the scope of the change, considerable study of the effectiveness and ramifications of the change is required. In some cases, project teams are assembled to develop and refine the proposed changes. Ideally, significant procedural changes are validated through simulations, with final vetting by the authorities in Ottawa. Consequently, the implementation of significant procedural change can be quite time-consuming.

During the field survey, there was wide-spread feedback on the degree of participation by operational controllers in the development of local procedures. Comments ranged from a complete lack of participation to others who had gained the experience of working full time for several months in the development of new procedures. Undoubtedly, there have been isolated cases where new procedures have arrived on the floor of the ACCs without apparent prior consultation and coordination. However, in all fairness, the system is simply far too complex to modify in any meaningful way in a managerial vacuum without input from those with the day-to-day experience. Although managers may alienate some personnel when they organize study teams which include working-level controllers, there is evidence to show that major airspace reorganization or procedural development generally takes account of workers' experience. However, whenever unpopular procedural changes are judged to be necessary, working controllers have a tendency to resist the changes, often using safety considerations as the basis for their disagreement.

8.2 COMMON PROBLEM AREAS

8.2.1 Non-compliance

Because compliance with standard operating procedures is the only guarantee of a coherent and coordinated air traffic system, the non-application of standard procedures for whatever reasons potentially compromises the overall integrity of the system. Blatant non-compliance is rare; however for a variety of reasons the prescribed procedures are not always followed. In their desire to accommodate traffic and provide the users with a high level of service, controllers may cut corners on prescribed procedures. As one controller said: " We make the system work by cheating and when it breaks down all the problems occur." For example, there was some evidence during the field survey that controllers were infringing upon longitudinal separation requirements on final approach to LBPIA in order to expedite traffic.

In their desire to expedite traffic, controllers sometimes create tight situations which can quickly degrade to a "non-compliance" situation. For example:

> On 09 April 1989 a Fokker F100 was cleared for take-off on runway 24 Right at LBPIA. A Boeing 727 was cleared for an ILS approach for the same runway. After receiving take-off clearance, the F100 pilot delayed take-off to conduct a static spool-up to provide heat for the engine intake de-icing systems before starting the take-off roll. A loss of separation occurred as the Boeing 727 approached the runway threshold and was issued landing clearance with less than the required minimum two mile spacing between landing and departing aircraft on the same runway.

During the field survey, it was evident to the investigators that controllers are generally highly motivated to provide service - sometimes service beyond their mandate which can therefore be in non-compliance with prescribed standards. For example, controllers at Gander spoke of providing terminal control service at Gander; while they are equipped and mandated to provide a radar control service, they are not expected to provide a full terminal service. The following is an example of an occurrence which resulted from a controller attempting to provide a service for which he was not responsible:

> On 15 January 1985, three technical losses of separation involving four aircraft occurred at Vancouver when the airport controller began applying airport control services to IFR aircraft for which he did not have responsibility for control. According to the Fact Finding Board, "A potentially hazardous situation exists owing to the differences of opinion with respect to who is to provide IFR separation between an IFR departure taking off on other than the active IFR runway and arriving IFR aircraft when departure has validated the departure clearance."

Some controllers commented on the number and types of separation criteria - many of which they find little occasion to use. Through lack of use they lose familiarity with these criteria and procedures and rely almost exclusively on their more frequently used "tools."

Individual interpretation of procedures can result in ineffective or non-application. Apparently some procedures are unwritten, such that one controller reported "It is difficult to enforce unwritten procedures; this leads to discrepancies in application." Another controller stated that "There's too much left to individual subjective interpretation and standard application does not result." One Toronto controller observed on the effect of staffing shortages on the application of procedures: "At this location when you're short of staff, you usually get a waiver on a particular procedure." All of these allegations, if true, reflect on the quality of supervision available in ensuring the application of prescribed procedures and operating practices.

Most controllers recognize the importance of the application of standardized procedures. Comments such as "the more the traffic, the more rigid the procedure must be applied" and "there's no room for personal procedures" are indicative. On the other hand, controller comments indicated that procedures are not always being applied in a consistent manner. Many blamed the lack of supervision stating "different controllers, different crews, different supervisors equal different application."

8.2.2 Resistance To Change

Where safety is paramount, air traffic controllers are understandably suspicious of any changes to procedures that have served them well over the years. Many controllers reported difficulty in adapting to change, overcoming years of previous experience following a 15-minute briefing. As one senior controller stated "After 15 years of working with a given procedure, it becomes very mechanical."

Sometimes change is perceived as a diminution of a controller's authority. Some controllers believe that some new procedures are introduced to protect weak controllers. In one Centre, there was feedback concerning the macho image of some controllers. After working in one specialty for 15 or 20 years, it is not surprising that the "hot shot prototype controller" could emerge with personally developed procedures for handling heavy, complex traffic. Forcing such controllers to apply new procedures the same way as a recently checked-out controller in the specialty tends to pique individual egos. One controller reported "the loss of professional pride resulted in a near fist fight between controllers on the new procedures."

Notwithstanding the strong emotions associated with major procedural changes, once the initial resistance to change is overcome, suitably validated procedures are accepted and effectively implemented. Recent examples of this include the new vertical separation criteria for parallel ILS approaches at Toronto and the standard application of a 40 mile range (versus the old 60 mile range) in terminal control sectors.

Operational controllers expressed a widespread sentiment that the non-operating side of the ATS organization has been far too ready to change procedures after an incident, when the failure was too often that of an individual not applying a procedure correctly. These controllers perceive many of the changes as unnecessary, creating extra workload with a loss of flexibility to the controllers. As one controller stated "procedures shouldn't be invented to prevent controllers from controlling." Others saw a rather circuitous evolution in procedures with change after each Fact Finding Board slowly bringing the procedures back to the original form. For example, some controllers believe that the criteria for assigning altitudes inappropriate for the direction of flight were in a constant state of change for several years; it is Transport Canada's view that the criteria have not changed, but their application has varied from time to time across the country.

8.2.3 Competence Of Procedures Specialists

Several controllers expressed the view that those tasked to develop new procedures had neither the depth of understanding nor the experience necessary. Typically one controller stated "The procedures are developed by people who do not have the necessary knowledge and these procedures are imposed on the controllers." Another noted that "Personnel responsible for developing procedures should like the job, rather than just being assigned to it."

Again, the Investigating Team found little or no concrete evidence to support the allegation. Recent staff reductions have resulted in some Unit Operations Officers' positions being unfilled, and some of the Unit Operations Officers in place may not be particularly well-suited to procedures development. On the other hand, the "project team" approach adopted by Montreal ACC with respect to new procedures for the North subunit is indicative of employing the most competent people to address the operational requirements. Indeed, notwithstanding any criticism of the process for developing new procedures, the system seems to be evolving reasonably well.

8.2.4 Implementation Of New Procedures

Each year there are several significant amendments to the ATC Manual of Operations (MANOPS). Generally these changes are issued to ATC units in advance of their effective date in the form of an Air Traffic Service Directive (ATSD). Notwithstanding the prior coordination and consultation that may have gone on in preparing for the procedural changes outlined in the ATSD, ATC units still have an opportunity to comment on the changes prior to their implementation.

Notwithstanding the consultative process, in the case of ATSD 008 issued in April 1989, it was received at one centre four days after its effective date. Furthermore, the ATSD was reported to be available only in the French language for Montreal ACC and contained several anomalies warranting further amendment and clarification. It would appear that this was an isolated incident. However, oversights of this nature can mean that controllers, on occasion, may be using procedures that are significantly different than procedures being used in an adjacent unit.

When significant changes are introduced, such as those of an ATSD, ATC units are faced with a problem of disseminating the information in a timely and effective manner. Complex procedural changes, e.g., those involving major sector or airspace realignment projects, require thorough briefings. Indeed on a national basis, Transport Canada in Ottawa frequently flags significant items for "mandatory briefing." However, briefing more than 150 controllers in a large centre in a uniform manner poses major organizational and communications challenges. Controllers arrive and depart at as many as eight different times over a 24 hour period, depending on their shift cycle. They are regularly scheduled for four days off at a time, they take their annual leave, and occasionally take sick leave, etc. Mass briefings of all personnel are simply not practicable.

When the procedures are particularly difficult or complex, a controller with special knowledge or experience may be required to participate in the briefings - explaining the finer points of the procedural change. Unfortunately, such specialists cannot be available 24 hours a day for as many as 30 days simply to reach all controllers. Therefore, shift managers or others are often tasked to explain detailed projects with which they themselves may have but a cursory understanding. When they are unable to elaborate in the same detail as an expert, the new procedure may be challenged and the briefer can lose the credibility and respect of those being briefed. There are no simple solutions. However, given the criticality of a common understanding and a common application of new procedures, consideration should be given to the employment of video-recorded briefings or computer-based training packages for items requiring a "mandatory briefing."

Following is an example of an occurrence where the introduction of new procedures may have been a contributing factor.

> On 07 June 1985, a loss of separation occurred between a Boeing 767 and a Boeing 747 at FL370 en route eastbound approximately 55 nautical miles north of St. Anthony, Newfoundland. The utilization of new high-level domestic procedures in Gander ACC was reported as an unusual circumstance by the Fact Finding Board and discussions concerning a planned sector split were reported as a distraction. Apparently, the utilization of revised high-level domestic procedures during a period of moderate to heavy traffic probably added a degree of confusion and extra work load due to the inexperience of the controllers with the new procedures. Furthermore, the new procedures may have complicated the decision making process which resulted in an apparent delay in splitting the sector when required.

Such occurrences raise the question as to adequate familiarity with a procedure before implementing it. Is it wise to practise new procedures under moderate to heavy traffic conditions? Should some form of experience with the new procedure be acquired at lower traffic levels and complexities, perhaps through simulation, before attempting to use the procedures with moderate to heavy traffic?

> On 26 April 1989, in the Montreal terminal area, a Fokker F100 was authorized to climb to an altitude of 7,000 feet on a converging trajectory with a CL215 which was climbing on a reciprocal heading. The two aircraft passed within 300 feet of each other.

> The CASB investigator has submitted a Safety Deficiency Notification concerning the adequacy of the training for the new procedures being implemented in the ACC at that time. In particular, he was concerned that the simulation session was incomplete and lacked reality. (As noted in Chapter 4, the simulators at the regions lack the fidelity of the simulators in the Research and Experimentation Centre in Hull, Quebec)

For minor or routine changes to procedures, upon reporting for work controllers are required to sign in and to "sign as having read" any procedural changes, thereby indicating a "complete understanding" of the procedure.

Given the natural resistance to change after 15 or 20 years experience working with an old procedure, it is difficult to expect a controller to automatically apply the new procedure five minutes later upon assuming control duties. As one Toronto controller reported "There is confusion on standard profile descents, STARs, and radar vectors as to which is still valid when the other is implemented."

The problems of information dissemination to operational personnel is not unique to air traffic control. Pilots too must be able to adapt their operating methods in accordance with changes - sometimes received through NOTAMS just prior to flight. Nevertheless, given the importance of standard operating procedures to effective air traffic control, considerable extra effort is required to ensure that all controllers involved do have a genuine understanding of new procedures and an ability to apply them upon assuming their control duties.

8.2.5 Transfer Of Control

One area of concern that frequently arose during the field survey phase concerned the transfer of control from the IFR arrival controller to the tower controller under instrument meteorological conditions (IMC).

Under VMC, once an airport controller has sighted an IFR arrival, a visual approach may be authorized and control of the arrival aircraft transferred to the airport controller. Visual separation criteria rather than instrument separation criteria are then applicable. This greatly assists in the expeditious flow of traffic. For example, IFR aircraft awaiting take-off can be released with less than the required IFR separation from the arriving aircraft.

Under IMC, transfer of control should not occur until the aircraft touches down on the runway. However, the transfer of communications from terminal to tower normally occurs at some earlier point. The point at which the transfer of communications is to occur is defined in a written agreement between the tower and the Centre. With such written agreements, verbal coordination requirements can be greatly reduced, especially if this transfer of communications is automatic. This procedure has apparently been a source of confusion for some time. For example, at LBPIA it is normal for a pilot to be instructed to change to tower frequency as the aircraft passes the outer marker. Control of this aircraft under IMC, however, remains with the arrival controller. The responsibility for the separation of such aircraft does not appear to be clearly understood by controllers as illustrated by the following three occurrences:

- In an 11 October 1985 occurrence at LBPIA, an assumption was made that a "hand-off" was not necessary since the installation of a radar display allowing the airport controller to monitor the arrival radar display. Hence traffic information was not exchanged.

- In a 19 April 1985 occurrence at Vancouver, the Fact Finding Board was of the opinion that the arrival low controller expected the airport controller to request control of one or both of the aircraft involved when he asked the tower if the Air Canada flight was "going to make it." According to the Fact Finding Board: "There appears to be a misunderstanding on the part of the arrival low controller as to the application of separation between successive IFR aircraft cleared for an approach."

- In a 3 February 1987 occurrence at LBPIA, the Fact Finding Board found that "two losses of separation were caused by the maintenance of radar separation in a manner which was accepted by the controllers as the normal operating practice (i.e., separation to the outer marker) in lieu of the requirements set forth in MANOPS which require separation in IFR weather conditions to be maintained until the aircraft have landed. The controllers' interpretation of the Tower/Terminal agreement does not distinguish between IFR/VFR weather conditions; however, logic should dictate that it is impractical to effect an automatic transfer of control to the tower at the outer marker when the weather is below VFR weather conditions."

Some controllers have concern as to who is responsible for control of the aircraft in the event of a missed approach, possibly due to runway traffic conditions? Tower controllers are naturally reluctant to accept responsibility for directing an "IFR" aircraft, and the departure controller may have difficulty integrating the aircraft on missed approach back into the IFR flow with the required IFR separation. Indeed, following the previously mentioned loss of separation occurrence in Vancouver on 19 April 1985, the Fact Finding Board concluded "The absence of specific missed approach instructions being issued to Air Canada by the airport controller had the potential of causing confusion in both the cockpit and the terminal and could have resulted in a more critical situation." During the field survey, Toronto controllers complained they had sought clarification on this question of responsibility (including submission of an Operational Condition Report (OCR)) without satisfaction; (Transport Canada officials reported not having received this OCR at their level and were therefore unaware that further clarification might be warranted.)

In view of the apparent confusion extant and the doubts expressed regarding transfer of control from terminal to tower controllers, clarification is required.

8.2.6 Sector Opening / Closing

During the field survey, considerable feedback was received with respect to inadequacies of existing procedures for opening and closing sectors. Considerable judgement is required with respect to the timing of sector opening and closing. Such judgement is dependent upon effective supervision. However, as discussed in Chapter 7, Supervision, there are serious shortcomings in the quality of first-line supervision available in the Centres today. The following remark is indicative of feedback received from controllers: "The split sector syndrome requires waiting for chaotic conditions to develop before opening up a new sector."

In view of the time required for the Data Systems Coordinator (DSC) to make the necessary equipment configuration changes considerable lead-time is required to make a decision in opening a sector prior to the arrival of the peak traffic demand.

The opening of a new sector also requires the availability of controllers qualified on that sector. Non-availability of a qualified controller has contributed to occurrences in the past. For example:

> On 25 June 1988 separation was not assured between a Boeing 727 and a DC-10 at FL310 in Gander Ocean Sector 95. The controller was working at Pace Level 5 and did not detect the confliction when he approved FL310 for the Boeing 727. The Fact Finding Board found that one of the factors contributing to the occurrence may have been the requirement to assign an ocean qualified controller to the Low Level Domestic Specialty, thereby preventing a resectorization of the oceanic area to more evenly distribute the workload when traffic began to increase on Sector 95.

The Investigators heard anecdotal evidence that supervisors working an active control position were sometimes being trapped at a control position, unable to open a new sector because they were too busy. (See Chapter 7, Supervision.) Qualified controllers were apparently available in the Centre on a relief break, but the supervisor was too busy to recall them to open a new sector. Conversely, there is some evidence of premature closing or recombining of sectors. In Gander, for example, as the eastbound transatlantic traffic flow begins to decrease, there is a desire to let controllers go home early; this results in increased workload for those remaining - at a time of day when their operational efficiency is probably at its lowest; i.e., 4:00 to 6:00 a.m. Such considerations may be more a reflection of the quality of supervision than the local operating practices for sector opening or closing.

The effect of handing over responsibilities for aircraft in a particular sector to another controller always requires thorough sector briefings. The need for good sector briefings is particularly acute during the opening or closing of a sector. As one controller stated "The condensing and opening of sectors is a time when the system could be vulnerable; information and data transferred is vital and has to be correct." Yet the file review showed several occurrences attributable to inadequate sector briefings. The following is an example:

> On 29 July 1985 a critical loss of separation occurred between a Boeing 747 and a Boeing 707 when the Boeing 747 was cleared to climb to FL370 and passed the Boeing 707, opposite direction traffic, at the same altitude. According to the Fact Finding Board report, the primary cause of this loss of separation was that the controller on Sector 93 failed to provide the controller on Sector 92 with the required data when Sector 93 was split and Sector 92 opened. As the controller who opened Sector 92 had no data on the Boeing 707, he was not aware of conflicting traffic when he issued the clearance for the Boeing 747 to climb to FL370. The Fact Finding Board noted that "this may not have been an isolated situation as there was an indication from those interviewed that there have been other instances when flight data were not duplicated and provided to the new sector on a timely basis following a sector split."

Transport Canada subsequently issued an Operations Bulletin cautioning controllers to be more vigilant and to exercise caution to ensure that all pertinent data are transferred during a sector split. Further problems with respect to information transfer during sector opening and closing are discussed in Chapter 10, Information Transfer. However, from a procedural point of view, directing controllers to be more vigilant, to communicate and coordinate fully, etc. may be missing the point completely. To the extent practicable, the procedures must be designed so as to take account of normal lapses in controller vigilance and judgement.

8.2.7 Coordination Procedures

Of the 52 occurrences deemed to have procedural-related contributory or cause factors during the CASB file review, at least 16 had coordination-related problems. In many cases, inadequate procedures existed to effect the necessary coordination; in others, prescribed coordination procedures were not followed. The ATS Branch has recognized ongoing problems in ATS coordination and had issued ATC Safety Bulletin No. 8901 on coordination problems earlier this year. This safety bulletin addresses many of the issues raised in the discussion on inter-controller coordination of Chapter 10, Information Transfer. However, the procedural aspects of coordination may be more fundamental than controller discipline.

As air traffic increases, there is a logical tendency to open more and more sectors of smaller dimensions to keep individual workload manageable. However, this process can have a down-side of increasing coordination requirements among controllers, increasing frequency changes for pilots, etc. A fundamental re-examination of ATS system requirements is required with a view to reducing overall coordination requirements - either through increased reliance on automated equipment or through further procedural refinement. This issue of reducing controller workload through improved strategic operational planning is discussed further in Chapter 11, Management.

8.2.8 Wrong-way Altitude Assignments

To cope with the volume and complexity of traffic to and from international airspace and the volume of traffic between selected city pairs, ATC MANOPS provides for the assignment of altitudes inappropriate for the direction of flight, but under stringent conditions. Nevertheless, losses of separation continue to occur when altitudes inappropriate to the direction of flight have been assigned. In a 1987 Aviation Safety Advisory, the CASB noted six such occurrences during the preceding two years. For example:

> On 05 August 1987, a Boeing 747 and a DC-10 were involved in a near miss near Halifax, Nova Scotia while in level cruising flight at FL350). The aircraft were cleared on opposite direction tracks at the same flight level and the confliction was not detected by controllers until the aircraft were about 35 miles apart. As communication could not be immediately established with the DC-10, the B747 which was eastbound at an inappropriate altitude for direction of flight was instructed to turn in order to avoid a potential collision.

At that time, controllers interviewed expressed reluctance to refuse any pilot's request for altitudes inappropriate to the direction of flight, contrary to existing procedures. Others suggested that there is managerial pressure to condone wrong direction altitudes in order to accommodate high traffic volumes. In the opinion of others, strict compliance with wrong direction directives imposes such constraints on traffic flow that expeditious control of high-level air traffic is nearly impossible.

Evaluation studies conducted by Transport Canada between December 1985 and August 1987 suggest that inconsistent application of ATC directives re wrong-way altitudes is a nation-wide problem, not confined to a specific geographic area. Regardless of the reasons for any such non-compliance with established directives and procedures, safety margins can be dangerously eroded when established procedures are not complied with. The high closing speeds involved with two aircraft flying in opposite direction at the same flight level demand the highest level of controller concentration. Any controller distraction, non compliance with established procedures, or breakdown in the information transfer process between controllers or between controllers and air crew can create a critical, high-speed, head-on traffic situation in a few seconds.

Transport Canada has recognized the potential danger in these procedures. Consequently, an ATS Safety Bulletin No. 8801 was issued reminding controllers of the need for strict adherence to ATC MANOPS directives with respect to inappropriate altitude assignment for direction of flight.

Controllers' views on the required procedures vary. One ocean controller found the oceanic applications to be clear but found non-standardized application in domestic airspace, dependent upon individual controllers and crews. Others found the current directives too constraining; the related heavy coordination requirements can be time-consuming and frustrating.

Altitude assignments inappropriate for the direction of flight require extraordinary vigilance. In at least one case, controller preoccupation with the altitude assignment precipitated an ATS operating irregularity:

> On 16 July 1988 a loss of separation occurred between a Boeing 747 and a Boeing 727 at FL330 in the Northern Control Area. The Fact Finding Board determined that the cause of the loss of separation was that the second northern control area North Sector Controller did not pass the estimate on the Boeing 747 to Montreal ACC because he was preoccupied with the Boeing 747 being assigned an altitude inappropriate to the direction of flight.

The continuing desire of some controllers to "bend the rules" to accommodate traffic by assigning altitudes inappropriate for the direction of flight is cause for concern. In the absence of an effective conflict prediction capability, it would appear that only rigid application of the directives in ATC MANOPS can ensure the necessary safety margins - especially given the high closing speeds of high-level en route traffic today.

8.3 SITE SPECIFIC PROBLEMS

8.3.1 General

Local procedures and airspace sectorization are in a constant state of flux in an attempt to accommodate local changing traffic patterns. Over the past two years, three of the four ACCs visited have undertaken major studies and effected significant changes in airspace utilization, sector layout and controller responsibilities and procedures. When a major change is implemented, associated changes are frequently needed in adjacent ATC units. For example, significant changes in the procedures for the handling of aircraft in the Northern airspace of the Montreal FIR have had a concomitant effect on traffic going to or coming from the Gander ACC, the Toronto ACC, and even the Edmonton ACC. The current centralization of responsibilities of IFR procedures at the National Headquarters seems to be a logical step for overseeing and coordinating the necessary associated changes.

8.3.2 Toronto

8.3.2.1 Sectorization

Some sectors to the West of LBPIA have recently undergone a realignment to accommodate the military activity off Niagara Falls, New York. This realignment involved the assignment of some American airspace to Toronto ACC and consequently increased the flexibility and manoeuvring space available to the affected sectors.

A traffic flow reversal for aircraft operating in the Toronto/ Windsor/Detroit/Toronto pattern is in the advanced stages of development. Upon completion, many controllers believe that the introduction of a basic one-way traffic flow both east and west will greatly facilitate the movement of air traffic operating in their area of responsibility.

A Transport Canada study of changes in traffic flow to the east of Toronto indicated that any significant modification would have an impact on the traffic patterns and procedures for adjacent facilities. Implementation of such changes would require time-consuming planning and coordination, as well as detailed simulation by all the affected parties. In the interim, the current traffic pattern does permit the maintenance of an orderly flow of aircraft between Toronto and points east.

8.3.2.2 Terminal Procedures

During the field survey, Toronto controllers reported that planning was currently underway for a resectorization of the airspace in the Toronto Terminal Specialty. Consideration is being given to splitting the airspace into north and south arrivals by an imaginary line drawn between the parallel runways. If such a configuration is adopted, a controller would be dedicated to each ILS localizer with a "sequencer" (a form of coordinator) assigned to help balance the load between the two arrival positions.

As mentioned earlier, in January 1989, following several occurrences involving simultaneous parallel ILS approaches, the CASB recommended measures to maintain vertical separation; (CASB 89-01 and CASB 89-02). Transport Canada responded immediately and implemented procedures to effect the necessary vertical separation during simultaneous parallel ILS approaches, and it is understood that the new procedures are now working effectively.

The CASB has received considerable feedback from pilots concerned about inadequacies in procedures at Toronto. A number of confidential reports to CASRP have been received which cite complicated and confusing ATC procedures at LBPIA. For example, one holding procedure that is apparently causing confusion for crews approaching Toronto from the east involves a clearance to hold at COEHILL with an expected approach time for the SUNDE intersection. The pilots miss the significant point in the clearance that requires them to be at SUNDE, (not to leave COEHILL), at their expected approach time and consequently they are late arriving at SUNDE. They believe that the expected approach time issued by ATC should be for the clearance limit, not for some point further along the route.

Although the STARS and Profile Descents at Toronto were developed in consultation with CALPA, ATAC and Air Canada, they were reported to be unnecessarily complicated and confusing so as to constitute a hazard to safety. Flight crews feel that they spend too much time with their heads in the cockpit trying to understand and follow the directions on the approach plates. There is a common concern among pilots with respect to the charting and depiction of STARs in general. To make matters worse, they are reportedly often given a vector or altitude amendment to the STAR or Profile Descent, with no indication as to which portions if any of the STAR or Profile Descent is still in effect. They seek more simple and user-friendly STARs and Profile Descents. Furthermore, since some controllers reportedly are not using the Profile Descents, pilots would like to see more consistency in their application.

The SIDS, currently in the Canada Air Pilot, require the pilot to maintain 5,000 feet on one portion of the plate while the specific instructions for runway 33 indicate that the aircraft is to climb to 3,000 or 4,000 feet depending on the direction of flight before commencing their turn; however, they are required to maintain 5,000 feet. Confusion results as different pilots interpret these SIDs and fly at different altitudes. Air Canada has reportedly addressed the problem by issuing printed explanations of the SIDs for their pilots. Pilots report that the instructions for each runway should include the altitude the aircraft is to maintain.

Pilot feedback through the CASRP concerning the quality of ATS at Toronto is also cause for concern. Late coordination of clearances for the approach have been frequently cited. The CASRP has received reports of aircraft overshooting the localizer into the path of the other localizer, confusing clearances, and late notices of runway changes that have left the crews unable to properly brief for the approach. At times, the frustration of the controllers manifests itself in noticeably unfriendly service. Such reports are from experienced international pilots who regularly fly into Centres as busy as LBPIA. They mention the strain caused by complicated procedures and clearances and express concern for those who may not be as familiar with the English language.

A STAR/SID symposium was held with representatives of the aviation industry in Toronto in October 1989 to discuss many of the foregoing problems. It is understood that a number of recommendations resulted from this symposium which are currently being addressed by Transport Canada staff. In particular, the direction for the development of SIDs and STARs is being amended with a view to making the procedures simpler. Additionally, the charts are being standardized for depiction and content. Also, the airway structure around Toronto is being modified to solve some of the problems created when STAR clearances are superseded by other clearances and instructions. Industry's representatives were highly supportive of this type of consultative process and involvement in the development of new procedures.

8.3.2.3 Flow Control

Although widely used in the United States, flow control is relatively new in Canada. Toronto uses flow control more than other Centres. For example, in late 1988, a cap was placed on arriving and departing traffic at LBPIA at 70 movements per hour. To minimize delays and reduce the requirements for aircraft holding while awaiting approach, departures destined to Toronto from airports such as Ottawa and Montreal are restricted.

Apparently flow control has experienced some growing pains. It is reported that at times aircraft are holding while the arrival controller is only moderately busy and that there are noticeable peaks and valleys in the sequence. Some controllers complain that there is no warning; e.g., one stated "Normal operations one minute, flow control restrictions the next."

For example:

> On 30 June 1989, a DC-9 and a B737 were both inbound to Toronto and were cleared for a Profile Descent on Runway 24. A loss of separation occurred when the radar controller issued a non-specific right turn to the DC-9, thereby compromising radar separation. The Fact Finding Board also found that a major factor that contributed to this loss of separation was the cancellation, with no prior warning, of all future inbound traffic from entering the terminal airspace. This severely limited the options available to the controller to successfully formulate and execute an alternate plan.

Since the Flow Control Sector is not part of the Terminal Specialty, there is some feeling that flow controllers do not understand terminal operations well enough. Some controllers believe that their methodology is too rigid and that greater flexibility is required. For example, it is conceivable that the controllers will handle their capacity of 70 movements per hour during the first 45 minutes of the hour; flow control restricts further departures for Toronto thereby creating a lull in the work for the controllers. There is some indication, that controllers now are accepting traffic under such conditions, thereby indicating an increased capacity.

8.3.3 Vancouver

Three overriding considerations affect operations at Vancouver procedurally. Firstly, the airport is essentially a one-runway airport with respect to handling large transport aircraft. Secondly, topography necessitates high minimum en route altitudes from all directions approaching Vancouver. Thirdly, of Canada's largest international airports, Vancouver handles a larger proportion of VFR traffic than the others; approximately one half of Vancouver traffic is VFR, whereas 19 per cent of Montreal Dorval traffic is VFR and virtually all traffic at LBPIA is IFR. Given the combined effect of these three characteristics with today's traffic levels, it is surprising that greater operating restrictions have not been placed on VFR traffic into Vancouver.

8.3.3.1 VFR/IFR Mix

Following a wake turbulence, fatal accident in 1984, the CASB determined that the absence of clearly specified separation criteria for mixing VFR and IFR aircraft in a radar-controlled environment constituted a serious safety deficiency. Therefore, the CASB recommended that:

> The Department of Transport issue criteria for introducing light VFR aircraft into a traffic pattern for landing behind heavy aircraft. (CASB 85-33)

In response to this recommendation, Transport Canada accepted the need to separate VFR and IFR traffic but rejected the need to impose new procedures.

Notwithstanding, difficulties with this VFR/IFR mix continue. For example:

> On 23 September 1988, a Dash 7 on IFR flight plan was on a left-hand visual approach on runway 12. An HS76 helicopter was inbound to Vancouver Harbour descending to 3,000 feet and in communication with Vancouver Terminal. The helicopter had to take evasive action to avoid the Dash 7.
>
> The Fact Finding Board determined that the involved controllers failed to remember the presence of the helicopter in time to detect the confliction. In addition, due to staff shortages, the Arrival Low position was not opened; the involved controllers were busy at Pace Levels of 5 and 6 and under such circumstances would give a low priority to VFR traffic; the arrival controller was working his ninth consecutive shift and the departure controller complained of working too long in position and working too much overtime.

Such contributory factors underline the need to find better ways of maintaining separation between VFR and IFR aircraft in and around Vancouver airspace.

Several controllers raised observations during the field survey of this investigation about the adequacy of the current system of 10 entry points originally designated in a VFR/IFR route study. The controllers find the system too complicated to control safely. They would prefer five or six entry points into the Terminal Control Area. It is understood that this situation is currently under re-evaluation at Vancouver.

A sector of the Vancouver Terminal Specialty controls the IFR traffic to and from the Victoria airport, 35 miles to the southwest of the Vancouver airport. This corridor over several of the Gulf islands is very busy; on days with good visibility conditions, dozens of light aircraft, both commercial and non-commercial, pass between the two airports on VFR flight plans. IFR aircraft, also operating at relatively low altitudes, must be continually vigilant to the possibility of encountering these light aircraft. Aircraft operating under VFR in this Class D airspace are not required to communicate with an ATC unit. Hence, Vancouver controllers suggested strongly that, for the safety of all aircraft flying in this area, the Vancouver Class C airspace (requiring two-way radio communications, and an ATC clearance) should be extended westward to Victoria's Class C airspace. With the current levels of VFR traffic, and notwithstanding the best efforts of the controllers, they are unable to adequately pass VFR traffic information to IFR aircraft. Since all such traffic information is passed on a time-available basis, they are also too busy to exchange IFR traffic information with VFR traffic.

The problem of the VFR/IFR mix in busy terminal areas is not exclusive to Vancouver. The Canadian Airspace Review (CAR) recognized the problem and made several recommendations related thereto. For example, CAR Recommendation 2.3.1.27 recommended that VFR corridor routes, where required, be established through Terminal Control Areas and that they be designed to remain clear of arriving and departing routes/profiles of IFR aircraft. Transport Canada plans to implement this recommendation in the summer of 1990. In addition, CAR Recommendation 1.2.1.17 recommended that Transport Canada, in consultation with the users, develop and publish criteria, procedures, and depiction standards for VFR helicopter routes in designated control areas and zones. The CAR implementation plan states that this Recommendation was implemented in November 1988.

CAR Recommendation 2.2.2.15 sought the provision of special procedures, VFR approach corridors, and manoeuvring areas on major airports, other than the main runways, that could be utilized safely and efficiently by general aviation aircraft. Transport Canada has not yet indicated a planned implementation date for this Recommendation.

The Confidential Aviation Safety Reporting Program (CASRP) has received several reports of near misses between IFR and VFR aircraft flying in Class D airspace in the vicinity of major terminals. One reporter, who was returning from a VFR charter at an appropriate altitude outside the Vancouver terminal area, observed a heavy passenger transport aircraft about two miles away on an apparent collision course. The reporter immediately made a 360 degree turn to the right, and, as he came out of the turn he felt the turbulence from the jet which he saw descending two miles away. The reporter considered that it can be like a "shooting gallery" to traverse that Class D airspace at certain times of the day. Similar occurrences have been reported around Toronto. In Class D airspace, traffic separation between IFR and VFR air traffic is based upon the "see and be seen" principle. As discussed in Chapter 9, Human Factors, this principle is less effective in busy terminal areas with today's large high-speed aircraft. At Vancouver, pilots may be completing a 15 hour crew day after a trans-Pacific flight and may be busy looking inside the cockpit while preparing their aircraft for the approach and landing. It is not reasonable to expect a sharp visual look-out by these pilots as they descend through the altitudes of VFR aircraft.

Recognizing the impact of increasing traffic volume at both Vancouver and Toronto, Transport Canada is attempting to amend ANO II No. 10 to require that aircraft operating in the airspace surrounding these airports be equipped with automatic pressure altitude reporting equipment responding to Mode C interrogations. This equipment would permit controllers to identify aircraft operating in proximity to each other. The altitude information is exchanged automatically, thus reducing the volume of information which must be exchanged verbally between pilots and controllers. At the time of writing this report, this amendment to the ANOs was still at the stage of having been promulgated for comment in Part I of the Gazette of Canada.

8.3.3.2 Departure Procedures

To expedite the flow of departing aircraft at Vancouver, an inter-unit agreement between the Tower and the Terminal Specialty grants Vancouver Tower controllers the authority to release IFR departures in accordance with strict guidelines. The tower controller is considered to be best able to fit the departures into a stream of IFR arrivals. While controllers had no complaint in principle, effectiveness is compromised by the fact that there is only one Standard Instrument Departure (SID) at Vancouver. Hence, it is difficult to expedite a mix of high- and low-speed traffic on departure. For example:

> On 22 September 1988, a Boeing 727 departed runway 26, and the airport controller released a Dash 8 off the same runway with less than the required radar separation. Traffic was heavy and fairly complex, and the controller was attempting to expedite departures between arrivals. When the Dash 8 became airborne, approximately 1.3 miles spacing existed between it and the Boeing 727. The airport controller, recognizing the lack of separation, attempted to obtain authority from the departure controller to turn the Dash 8. Fortunately, the speed differential between the involved aircraft soon established the three-mile spacing required.

The controllers believe that there is a requirement for either separate SIDs for high- and low-speed traffic or Tower Control should have the authority to fan IFR departures out with 15 degrees of separation prior to hand-off to the Departure Controller. (According to Transport Canada officials this latter suggestion can now be done.) Of note, CAR Recommendation 2.2.1.27 (that resources be provided to implement simultaneous parallel IFR departures) has been validated by Transport Canada for implementation. While this will expedite departures at Montreal and Toronto, it offers no relief for Vancouver in the absence of a parallel runway.

8.3.4 Montreal

8.3.4.1 Terminal Procedures

When the Investigating Team visited the Montreal Centre, some terminal controllers expressed dissatisfaction with the recent implementation of a 40-mile radar presentation (vs. the 60-mile presentation formerly in use). With the 40-mile presentation, controllers are no longer able to observe the inbound traffic before it enters their immediate area of responsibility. Some of them experienced a difficult transition to this presentation. Arrival controllers in particular were forced to depend on the en route sectors to regulate arrivals. It is believed that the improved radar vectoring on arrival is resulting in reduced workload for the controllers; Transport Canada officials report that the number of operating irregularities in the terminal area has dropped significantly.

Recent work measurements in Montreal indicate that the average Pace Levels for the same level of traffic have been reduced. One supervisor judged that this lessening of workload and its associated reduction in stress will permit controllers to remain in operations for a longer duration. Additionally, this reduction in workload should facilitate on-the-job training and check-out of new controllers in the Terminal Specialty.

One area of concern raised during the field survey phase of the investigation had to do with coordination requirements with as many as four controllers working the same vertical airspace. The loss of separation occurrence on 26 April 1989 involving a Fokker F100 and a CL215 (mentioned earlier in this chapter) is instructive. In this case, the Departure controller assumed that his colleague operating the Satellite position would provide the necessary separation. In the absence of a clear delineation of responsibility for control, inter-controller coordination problems and breakdowns in information transfer will increase the likelihood of such losses in separation. The coordination requirements in the Montreal Terminal Satellite Specialty require review.

8.3.4.2 Northern Procedures

With the advent of the latest generation of twin-engined wide-bodied jet aircraft (e.g., Airbus and Boeing 767) Extended Range Twin-Engined Operations (ETOPS) for trans-Atlantic flight were initiated. However, because of the requirement to maintain an en route alternate, these flights had to maintain a track closer to landfall, resulting in normal ETOPS transatlantic tracks considerably north of the North Atlantic track system. As this more northerly flow increases, it impacts heavily upon the Northern Sectors of the Montreal FIR. With the increased capabilities provided by the radars of the North Warning System at Saglek and Brevoort Island, procedures for the Northern subunit have been completely revised and were implemented during this special investigation. Notwithstanding significant staff shortages in the Montreal North subunit, these revised procedures in conjunction with the Northern Area Control System seem to have resulted in a significant increase in safe operating capacity.

8.3.5 Gander

8.3.5.1 Ocean Procedures

Generally speaking, sectors with responsibility to control aircraft over the North Atlantic tend to be highly pragmatic in design and operation. Once the twice-daily route structure has been defined by Gander and Prestwick, it will continue for the rest of that day. Nevertheless, as flights progress westbound, pilots frequently request altitude or route changes. As much as possible, controllers try to accommodate these requests, usually without problem. Over the years, practice and refinement of the procedures used over the North Atlantic have been well thought out. Aviation occurrences in Gander Oceanic Control tend to result more from controller inattention or forgetfulness, or pilot navigation errors. Given the limitations of current equipment for the controllers for communications and surveillance over the North Atlantic, the current procedures work reasonably well.

Concerns were expressed to the Special Investigators over growing international pressure to adopt 1,000-foot vertical separation (vs. the normal 2,000-foot vertical separation) in the oceanic control areas. While such a move would undoubtedly increase the capacity of the transoceanic system, it is believed that the accuracy of current altimetry would have to be further validated to warrant such a procedural change. In the longer term, given the necessary accuracy in altimetry and some form of real-time surveillance over the North Atlantic, perhaps 1,000-foot vertical separation will be acceptable from a safety point of view.

8.3.5.2 Gander Domestic Airspace

There are three radar sources serving the domestic airspace at the Gander ACC (Stephenville, Trepassey, and Gander). Neither the High-Level nor Low-Level Domestic Sector controllers have total radar coverage for the airspace under their jurisdiction, using only one radar source at a time. As a result, controllers are trying to apply radar separation criteria by selecting different radar sources, thereby leaving aircraft that were provided radar services from another radar source unmonitored. This practice is questionable from a safety point of view. Since the radar mosaicing capability of RAMP will only partially alleviate this problem, resectorization to eliminate this type of operation should be considered.

During a CASB investigation of a loss of separation occurrence between a Lockheed 1011 and a DC-10 at flight level 330 on converging tracks eastbound in Gander High Domestic airspace, an anomaly in the assignment of responsibilities was noted. The Gander High Domestic Procedures state that the data controller is responsible only for data board management and assisting the radar controller as required. With this arrangement, the data controller is only required to accomplish clerical duties. It does not allow the data controller any specific responsibility to plan the traffic flow within domestic airspace, to provide initial non-radar separation where required, or to alert the controller to potential losses of separation and conflict. Hence, while an extra set of competent eyes was available, the conflict between the two aircraft was not detected until a hand-off was initiated and a risk of collision situation was imminent.

Notwithstanding the current shortage of controllers, operating procedures should be such as to take full advantage of the competence available in two- or three-man sectors.

8.4 OBSERVATIONS

1. Transport Canada has evolved a rational and coherent system for the development of new operating procedures, including validation of significant procedural changes through operational simulations at the ATS Research and Experimentation Centre in Hull, Quebec.

2. As traffic increases to capacity levels, more rigid application of established procedures is required to maintain safe operations.

3. While the need for adhering to standard operating procedures is widely supported, there is evidence that controllers are cutting corners on occasion, trying too hard to get the job done or to provide a level of service for which they are not capable or responsible.

4. Many controllers interviewed hold a perception that unnecessary procedural change contributes to controllers' resistance to change and creates frustration and cynicism.

5. There are significant shortcomings in the current methods used to introduce procedural changes. Where mandatory briefings are

considered necessary, video recorded briefings or computer-based training programs offer potential relief. Furthermore, for complex procedural changes, "hands-on" familiarity in a simulator or introduction to the new procedures under light to moderate traffic may be warranted.

6. There is considerable diverse opinion among controllers as to the correct procedures to be followed with respect to the transfer of control of IFR aircraft from the arrival controller to the tower controller under instrument meteorological conditions.

7. Feedback from controllers indicated dissatisfaction with the quality of decision-making and timeliness in opening and closing sectors. Furthermore, there is evidence of inadequate sector briefings and data exchange when opening, combining, or closing sectors.

8. Coordination problems are a significant contributing factor in loss of separation occurrences. While non-adherence to accepted coordination procedures occurs too frequently, the problem may be more fundamental than controller discipline in complying with procedures.

9. Continuing controversy among controllers regarding the criteria and procedures for the assignment of altitudes inappropriate to the direction of flight is cause for safety concern. Apparently, pilots are often unaware of the absence of a safety net when they request this type of altitude assignment.

10. Several options for major resectorization of the Toronto air space are under consideration.

11. There has been widespread pilot dissatisfaction and confusion regarding arrival and departure procedures at Toronto; however, the situation appears to be improving.

12. Flow control procedures at Toronto need to be refined to provide a more even traffic flow.

13. Problems persist with respect to the VFR/IFR mix of air traffic at the busiest airports, in particular at Vancouver. Further control of VFR traffic operating in the vicinity of Vancouver is warranted, perhaps by extending the Class C airspace and requiring a Mode C transponder capability for aircraft operating in this airspace.

14. More flexible procedures are required at Vancouver in order to expedite departures.

15. Recently instituted procedures in the Montreal Terminal Specialty are reported to have significantly simplified workload there. However, coordination requirements involving the Satellite

Controller may be excessive in that up to four controllers may be controlling aircraft in the same airspace.

16. Recently instituted procedures for operations in the Northern subunit of the Montreal Centre have significantly increased safe operating capacity.

17. The practice of utilizing three radar sources to provide coverage of the Gander Domestic Airspace often means that aircraft operating under radar separation criteria are not provided with continuous monitoring as required by MANOPS.

CHAPTER 9

HUMAN PERFORMANCE FACTORS

9.1 GENERAL

The rapid growth of aviation following the Second World War was accompanied by a somewhat more modest growth in the study of human performance as it relates to the aviation environment. Originally this study of human factors was confined to aircrew, but as the air transportation system became more and more complex, the air traffic control system and the air traffic controller also became the subjects of considerable interest. The field of human factors, as it became known, grew to involve many disciplines, from physiology to psychology, sociology, ergonomics and engineering; research has delved into increasingly more subtle and specialized areas.

In the course of conducting research for this Special Investigation, it became apparent that there was a relative dearth of recent work on the human factors aspects of air traffic control. While some researchers, notably V. David Hopkins of the United Kingdom, have acquired an international reputation in the field of human factors in ATC, their findings often pertain to controllers' working conditions which are substantially different than the Canadian experience. The Special Investigators found little in the literature pertaining to the analysis of human performance factors as they pertain to air traffic controller's in the Canadian operating environment. Recognizing the importance of a sound understanding of the effects of human factors considerations on individual and group performance, it is understood that Transport Canada is planning to co-host a major international symposium on human factors in ATC in the fall 1990.

The review of Fact Finding Boards and CASB occurrence reports indicated that, just as for other types of occurrences, by far the most common contributory or cause factors in ATS incidents were those that involved the human in the system. Of the 217 incidents studied in the file review, contributory human factors were identified in 192 cases. These were in turn divided as follows:

Table 9-1
Distribution of Contributory Factors

TYPE	FREQUENCY	PER CENT
PLANNING	88	21.9
JUDGEMENT	75	18.7
INATTENTION	73	18.2
WORKLOAD	35	8.7
FORGETFULNESS	34	8.5
INFO TRANSFER	23	5.7
DISTRACTION	22	5.7
LACK OF KNOWLEDGE	16	4.0
FATIGUE	4	1.0
PERS PROBLEM	3	0.7
MORALE	1	0.2
PILOT-RELATED FACTORS	27	6.7

Note: Occurrences are often assigned more than one cause factor.

In addition, many other assigned factors were indirectly related to human performance; for example, a failure to effect proper coordination could be the result of faulty information transfer, or a pilot descending to an incorrect altitude could be partially attributable to "hearback" problems on the part of the controller, both of which are considered to fall into the general area termed human factors. (See Chapter 10 for a more complete discussion of those human factors relating to information transfer or interpersonal communication problems.) The field survey interviews with the controllers indicate that they too, are well aware of the importance of this aspect of their jobs.

In the United States, of the 1,213 ATC operational errors reported in 1987, almost 98 per cent (1,187) cited human factors as the primary cause (and similarly, 96 per cent in 1986.)[1]

Speaking at a symposium on Human Error Avoidance in September 1989, (sponsored by the Society of Automotive Engineers), the Honorable John Lauber, Member of the NTSB, pointed out that the role of human factors in ATC occurrences has not yet received enough attention; he cited the example of good controllers not seeing the intruding aircraft in the mid-air collision over Cerritos, California, even though a primary radar target was visible for several minutes. Given the widespread recognition within the United States of the need for improvements with respect to understanding human factors, the Federal Aviation Administration is currently developing a national plan to enhance aviation safety drawing upon the collective wisdom of the operators, the professional associations, industry and academia. This multi-disciplinary effort will include, inter alia, human factors research as it pertains to the design of ATC work stations; improved flight crew/controller methods for information transfer; improved selection, training and evaluation of controllers; improved maintenance and inspection of the ATC system, etc.

The focus of this chapter on human factors will be largely on those topics which emerged from the data and the controller interviews. Shiftwork, overtime, fatigue, stress, boredom, motivation and the work environment will be examined against the background of existing human factors knowledge. Any follow-up to the human factors problems identified in this report should be taken in the context of the current U.S. initiative described above to enhance human performance in ATC.

9.2 WORKLOAD

Several workload-related factors were discussed in Chapter 6, Staffing and Workload. Since the Special Investigation's file review of 217 incidents identified workload-related factors in 35 or 8.7 per cent of the occurrences, it is important to understand the human element of the workload issue.

With respect to controller workload, Kantowitz and Casper[2] have concluded:

> "Although it is difficult to find as many empirical studies that have measured air traffic control (ATC) workload as have measured pilot workload, the body of available literature suggests that ATC jobs require the same, if not greater, levels of mental workload as piloting an aircraft.....it appears that although monitoring objectively presents itself as a task with low associated workload, the internal cognitive activity it requires is quite expensive in terms of behavioral resources."

Apparently, the anticipation of impending control involvement is responsible for the increased mental exertion required of controllers performing the monitoring function.

Given the current staffing shortages discussed in Chapter 5, there is a natural concern about overloading controllers. However, according to V. David Hopkins[3]

> "Overloading is a problem at some air traffic control positions and must be resolved there, but many air traffic controllers encounter underloading and boredom more often than excessive workload. The reasons for reducing workload becomes somewhat obscure when examined. Most people who can

> control their own workload choose to be busy. To many, the successful performance of difficult tasks which require all their knowledge and skill is a highly satisfying and rewarding aspect of their jobs."

Indeed Weston noted that:[4]

> "... normally, controllers who may outwardly profess to aspire to a quiet life, can be seen "hunting" for traffic. This manifests itself in the rapidity with which controllers seek to combine sectors in quieter periods, thus enabling one controller to remain reasonably busy instead of two or three having little to do ... From an examination of near miss incidents it soon becomes apparent that a significant number involving controller error happen under conditions of light traffic loading. In other words, take away the stimulus of a traffic situation which demands controllers' attention and concentration and you probably raise the chance of controller error. Of course, it is essential to keep such a philosophy in context, for at the other extreme -controller overloading - the implications are much more serious ... the busier the traffic situation the less time is available for planning the tactical strategy necessary to deal with a given situation. Eventually the point is reached where the controller is struggling to react to situations as they arise with little or no time available to anticipate or plan for a specific pattern of events. Herein lies the real danger, the controllers' nightmare of "losing a picture".

It is difficult to predict at what point a controller will "lose the picture." There are many variables which contribute to a controller overload situation. Controllers do not have control over their own workload; hence the "Pace Factor" system described in Chapter 5 becomes important. Differences in individual controller capacity are also factors; e.g., training, experience, mental dexterity, reactions under pressure, fatigue level, etc. Indeed, at any given workload level, a minor distraction can create an overload situation. For example, the failure to elicit a response from an aircraft can distract a controller from more immediate and important tasks to a degree quite out of proportion with the gravity of the situation.

Preserving a controller's capacity to cope with high workload requires a balanced understanding of all the human factors discussed in this chapter. Pilots too have a responsibility to the controllers; for example, alert and crisp response to controller's instructions can help prevent critical controller distractions.

9.3 VIGILANCE

Although several different human factors were identified through this special investigation, one general area seemed to be overriding. Inattention, forgetfulness, lack of vigilance, or whatever name one chooses to call it, appears to be contributory in approximately 50 per cent of all ATS occurrences. Unfortunately, problems associated with maintaining constant vigilance are difficult to resolve because man is inherently badly suited for the monitoring function. It appears that man's reliability in performing tasks which require constant attention is poor. It is understood that in the U.S.A., the National Academy of Science is trying to define a series of studies on vigilance requirements in high performance tasks and the resultant fatigue effects.

Mr. David Hopkins of the Royal Air Force Institute of Aviation Medicine, writing on human reliability[5], has pointed out that:

> "Air traffic control shares with other complex installations, such as nuclear power stations and chemical processing plants, the need for very high reliability of the whole system, and of every component in it, including man."

Reliability figures such as one in 10 million or one in 100 million are frequently set and attained in aviation systems; e.g., one failure per 100 million events. However, reliability indices of one in one thousand or one in 10 thousand are more probable for human tasks.

The task facing the designers and operators of an ATC system is to achieve the highest possible reliability rate, or conversely, the lowest possible error rate, humanly possible, even though this will probably fall short of what is really required. Since mid-air collisions are extremely rare, the various redundancies built into the system are generally adequate to compensate for the shortfall. However, the increase in the number of reported operating irregularities, particularly in high density traffic areas, may be an indicator that the margin of safety is being reduced.

A FAA team lead by psychologist Richard Thackray discovered that vigilance tasks are stressful. People feel less attentive and more fatigued, irritated and strained after doing a vigilance task than they were before. People with laid back, Type B personalities are just as stressed by performing vigilance tasks as are rushed, competitive, Type A personalities.[6]

Thackray has also examined the effect of age on the ability to sustain attention to a complex monitoring task. The test visual display was designed to resemble an ATC radar display containing alphanumeric symbols. Subjects in age groups 18 to 29, 40 to 50 and 60 to 70 years were tested over a two-hour session. He found that the performance decrement was significantly related to age, with performance declining earlier in the session in the oldest group of subjects. Recordings of high movement activity, skin conductance level and subjective assessments of fatigue, boredom, monotony, and attentiveness generally failed to reveal any clear reasons for the greater performance decrement of older subjects."[7] In spite of the fact that reported fatigue (tiredness) was no greater among the oldest test subjects than among the younger ones, the most plausible explanation for the age-related decline in performance would still seem to involve some form of fatigue process. Simple habituation concepts do not appear adequate since numerous vigilance studies using auditory tasks, or visual tasks lacking a scanning requirement, have failed to show any age-related change in performance. Clearly, fatigue must be tied to the visual search requirement. In any event, given the demographic age distribution of the current Canadian controller population, vigilance-related occurrences can be expected to continue at a high rate.

When the problem of how to reduce errors of vigilance, forgetfulness, and inattention was put to the controllers during the field survey, they were uncharacteristically short of ideas, likely an indication of how difficult a problem it will be to resolve. The only two thoughts which consistently emerged were that:

- a full-time active supervisor would increase controller discipline and make the work environment more conducive to concentrating; (it has been suggested that many inattention errors are due to excessive "chatting" during periods of low traffic volume), and;
- well-rested controllers are less likely to make errors resulting from inadequate vigilance.

9.4 DISTRACTION

Closely related to the problem of vigilance is distraction. Of the 217 occurrences of this investigation's file review, 22 cases of distraction (5.7 per cent) were noted. The multiple tasks of the controller (i.e., monitoring, communications, flight data preparation, interaction with the computer, etc.) are highly vulnerable to distraction. In one study[8], several controllers indicated that they were aware of the potential for a situation to involve less than the prescribed minimal separation. However, since the distance between the aircraft was considerable, they decided to wait before they altered the course of one or both of the aircraft. Their attention then became focused on the other aircraft, and they forgot to issue the instructions that would have ensured adequate separation. There are really two ways to handle these situations: one is to train controllers to resolve a potential conflict as soon as it is detected; the second is to alert them to the potential effects of distraction and interference on their memory.

The following incident illustrates the potential dangers of such distraction:

> On 20 December 1988, a Boeing 737 was inbound to LBPIA, with a Boeing 727 which was established on final approach for runway 24 Left. Both aircraft were in descent when the 737 was turned across the approach path for runway 24 Left at LBPIA. The aircraft passed on crossing tracks with a vertical spacing of 600 feet and a horizontal spacing of approximately one mile. Apparently, the procedure used by the controller was such that it required continuous monitoring of the evolving situation; however, his atttention was diverted by other traffic in the arrival area, and he did not detect the conflict in a timely basis.

9.5 BOREDOM

> On 26 July 1989, a MacDonnell Douglas DC-9, inbound to Toronto, established contact with Toronto Arrival reporting an altitude of 7,000 feet. The aircraft was instructed to continue its heading of 260 degrees to intercept the localizer for Runway 24 Left and to maintain 6,000 feet. Meanwhile a British Aerospace BA31 Jetstream, also being vectored for Runway 24 Left at 6,000 feet, was given a heading of 220 which put it on a collision course with the DC-9. The aircraft conflicted with 100 feet of vertical separation and virtually zero horizontal separation.
>
> The investigation, which is still underway, has determined that this incident took place toward the end of the controllers shift, immediately following a period of heavy traffic. The controller stated that he simply did not remember instructing the DC-9 to descend to 6,000 feet. Traffic at the time was light, and both aircraft had functioning Mode C transponders.

This incident illustrates the paradox that ATC occurrences often happen during periods of light, non-complex traffic. The data relating inattention occurrences to Pace Level (see Table 3-11) indicates that 47 of the 63 inattention occurrences happened at a Pace Level of four or below; i.e., nearly 75 per cent of the inattention errors occurred under relatively low workload/complexity situations. A number of explanations have been offered for this, the most common being boredom, which in turn leads to inattention and lack of vigilance. As has been mentioned, man is a poor monitor and does not perform well at tasks in which he plays a passive role.

As system design leads to ever increasing automation, the requirement for human intervention and innovation becomes less and less. This can be seen, for example, in the control of ocean traffic where large numbers of aircraft move eastbound across the Atlantic on pre-determined routings that have been cleared of conflict by the Gander Automated Air Traffic System computer. Although there are some changes to these routings and some aircraft require manual handling, the ocean controller's job is essentially one of monitoring progress reports on 40 or 50 paper strips; it can be seen that complacency could creep in.

As mentioned earlier in this chapter, some controllers felt that good supervision was probably the most effective method to reduce the effects of boredom in this situation. Another solution would be to automate some of the monitoring functions; for example, the conflict alert capability of the Canadian Automated Air Traffic System. Such systems are typically equipped with sufficient warning devices to alert an inattentive controller of a developing conflict.

Controllers interviewed expressed concern over the practice of leaving controllers on a position for long periods during quiet times; they are concerned that errors caused by boredom could result. Controllers generally expressed the opinion that a maximum of two hours on a moderately busy position should be the norm, but that longer could be allowed when workload was light. It would appear from the occurrence data that boredom is as great a threat to safety as short-term fatigue. Perhaps staffing during quiet hours should be examined in this light.

9.6 SHIFTWORK

One of the realities that an ATCler must face is the requirement for shiftwork. Not only does the ATC system operate 24 hours per day, but in some Centres (e.g., those handling transoceanic flights) workload actually increases during what are normally quiet hours at other locations.

Much has been written about the effects of working outside of the period when the human body is normally expected to be at rest, both in the ATC environment and in other occupations which must function around the clock. Most of these studies discuss the various physiological phenomena associated with disturbances of normal body rhythms and their effects on work-related functions. Although this type of information is interesting in an academic sense, the most useful information in the context of this investigation is that which addresses the problem of how to design a system which minimizes the adverse affects of the disturbances of body rhythms related to shiftwork.

The several different shift patterns in use in the Canadian ATC system are described in Chapter 5, Staffing and Workload. The most common is a five-day working cycle, usually arranged in what is known as a 2-2-1 system; i.e., two evening shifts followed by two day shifts followed by one night shift. There are many variations of this basic system that have evolved over time with the concurrence of both controllers and management. The advantages of this system are that time-off is at a maximum, and the fatiguing effects of the one night shift are left to the end of the cycle when a longer rest period is available. Another system, often used in combination with the first, is a cycle of five straight shifts of the same type (e.g., straight days). The major advantage of this system is that there is more time to adjust to whatever shift one is on. In a study done in the United States which measured stress levels in two ATC centres operating on these two systems, there was found to be little to choose between the two.[9]

Attempts to evaluate the relationship between operational errors and time of day have generally proven futile. The amount of traffic during the midshift is usually so low as to make meaningful rate comparisons impossible. As an example, of the occurrences in the data base of this Special Investigation, only 36 of 705 (5 per cent) happened between midnight and six A.M. This may, in fact, be an indication that controller performance does not significantly deteriorate outside the normal hours of wakefulness. An explanation for this is offered by David Hopkins:

> "air control, consisting mainly of cognitive tasks with a high storage load, epitomizes the type of job most resistant to disturbance by erratic work-rest cycles, and that if work-rest cycles do become so extreme as to begin to affect performance it is peripheral and incidental unmeasured aspects of it that are most likely to be influenced".[10]

He concludes that acceptability by the controllers is probably the determining factor. Thus, it would appear that given the operational necessity to work shifts and the lack of data linking occurrences with any particular time of day or night, the existing shift systems are adequate.

Controllers interviewed expressed little dissatisfaction with their shift systems, and it appears that shiftwork with its disruptive effects on social and family life is an accepted fact of life for most controllers. The 2-2-1 system allows for a generous amount of time off, especially when the full four days off are taken. It is, however, the four days off which have become the major source of concern when attempting to address the subject of fatigue and its relation to controller alertness and forgetfulness. If the four days off are days of rest, then the effects of shiftwork are minimized. If, however, a controller works during what is supposed to be a period of recuperation, then there is cause for concern.

Of almost universal concern to all the controllers interviewed was the amount of overtime required to make the system operate today. Excessive overtime is considered to be an inappropriate use of time off, and only exacerbates the naturally fatiguing effects of shiftwork.

9.7 OVERTIME

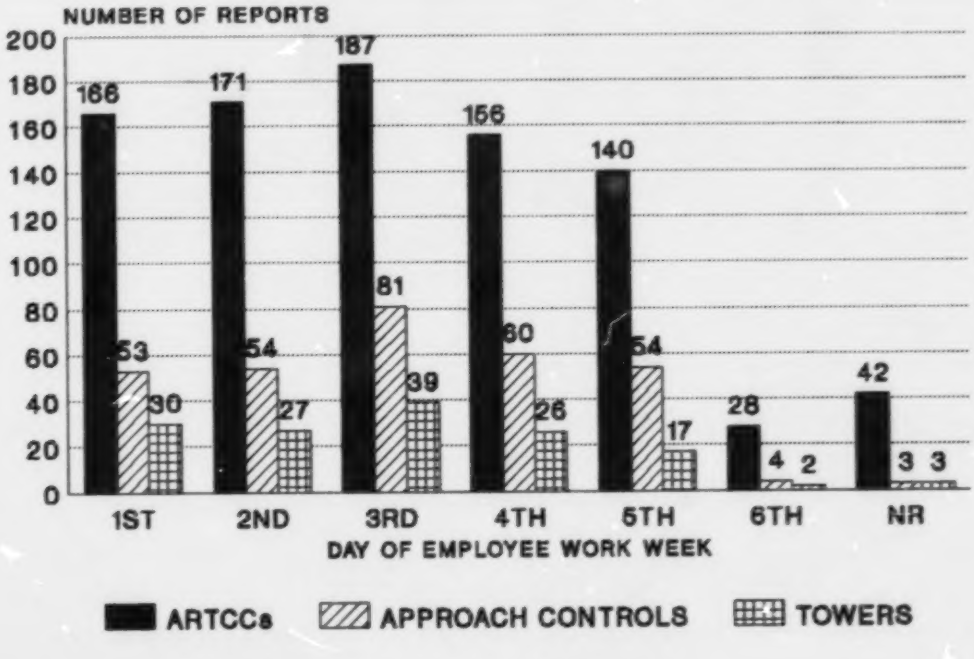
The amount of overtime being worked by controllers is discussed in Chapter 5, Staffing and Workload. The question of interest in this chapter is whether overtime is detrimental to safety or, more realistically, at what point does performance degrade below an acceptable level when a controller works large amounts of overtime? There is no doubt that many controllers are routinely working what a layman would consider to be a staggering number of shifts doing work requiring a high degree of concentration. Yet, there is considerable pressure on the controllers to work extra shifts overtime. Given current staff shortages, if someone does not do his or her share, others have to do more just to keep all required sectors open. As well, there is peer pressure to work overtime to facilitate the summer leave program.

Since the controllers' collective agreement calls for time-and-a-half for the first day of overtime, double time for the second, and double-and-a-half for any additional, there is considerable incentive for controllers to "gang load" their overtime. For example, rather than work two shifts during a four-day rest cycle, controllers cooperate in manipulating their availability so as to work four shifts and then take all four days off during the next rest cycle. This, of course gives the controller more money. It also leads to longer periods of consecutive work. Many controllers suggested that the payment of double time for all overtime would eliminate this practice.

In interviews, most controllers and supervisors estimated that, on average, they expected to be working five to six overtime shifts per month. Since the regular work week for controllers is 34 hours, the addition of 1.5 shifts, or approximately 13 hours, produces a work week of 47 hours.

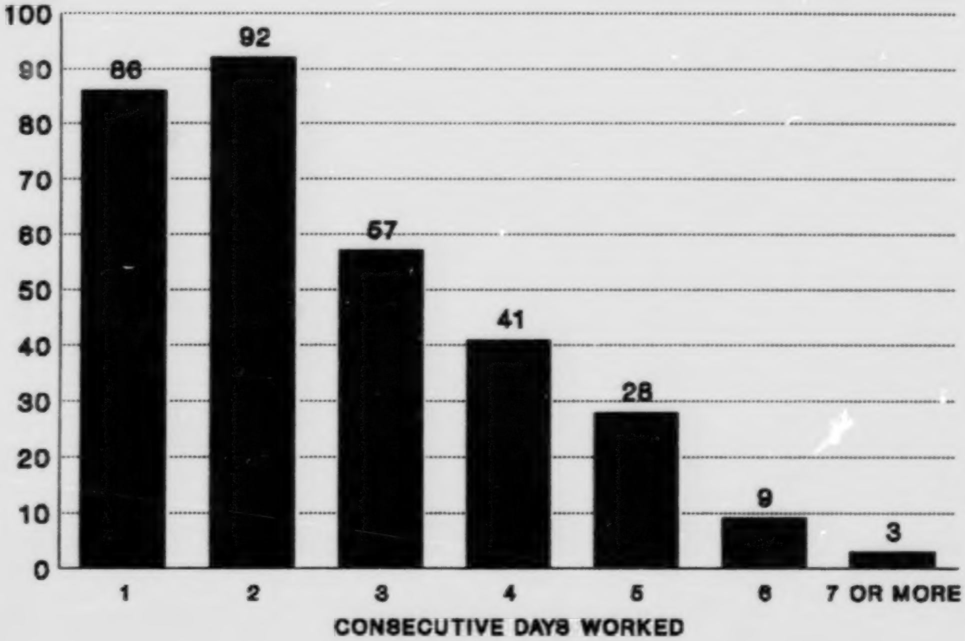
There is some research into the effects of controllers working this number of hours. Data from the United States relate the number of operational errors to the day of the work week in which they occurred, and, since controllers in the U.S.A. commonly work a six-day work cycle, the total number of hours equates roughly to the average of 47 hours worked in Canada by controllers who work overtime. This data, which are shown graphically below, indicate that most operational errors occur during the first three to four days of the work week:

TABLE 9-2
OPERATIONAL ERROR REPORTS 1986
BY DAY OF EMPLOYEE WORK WEEK BY
FACILITY TYPE



Canadian data, shown below in Table 9-3, reflect a similar pattern, though the fall-off through the fifth and sixth working day is more pronounced than in the U. S. A.:

TABLE 9-3
CONSECUTIVE DAYS WORKED-DAY OF INCIDENT



At first glance, a cynic might conclude that the risk of operating error is significantly reduced the more one works. It must be pointed out, however, that, with each increase in "consecutive days worked", there are fewer controllers who have worked that number of days. For example, the population of controllers who have worked more than five consecutive days is known to be a small fraction of those who have worked at least one day.

Furthermore, data on controllers working in excess of six days ARE either not available or ARE simply too small a sample to be statistically relevant. Hopkins[11] notes that this lack of data makes it difficult to support any justification for reducing working hours. It appears though that he is assuming that controllers typically work a 40-hour week as is the case in Europe.

With respect to Table 9-2, the drop-off in numbers of operating irregularities after the first three or four days of a working cycle does suggest that there is some kind of a "getting back on the step" phenomenon at work. Furthermoro, the relatively high number of incidents during the first two days draws into question the controllers' use of time-off. Is four consecutive days off too many? For example, is a controller's timing affected by these days off? Are controllers using their days-off as days of rest to recuperate from their rotating work cycle? Are controllers pursuing secondary activities during their time-off which undermines their effectiveness as controllers?

Despite the absence of hard data regarding periods of work in excess of six consecutive days, the impression gained during the course of the interviews with the controllers, supervisors, and managers was that, in many cases, the amount of overtime being worked was excessive and constituted a safety hazard. Many controllers acknowledged that they often worked 12 to 14 overtime shifts per month. This works out to an average work week of approximately 60 hours. This number may not seem excessive for someone performing routine tasks, but, when coupled with shift work and the requirement to be mentally alert, it should be cause for concern. Most controllers on this type of schedule admitted to feeling fatigued. They likened it to being on treadmill; "All I do is work, eat, and sleep" was a common comment. There were controllers who described a kind of "high" when they were in this cycle and felt that their mental processes were particularly acute, that they were "in the groove." Some admitted to difficulty in returning to normal family life and that it was simpler to just keep on working.

A universal view, however, was that this pace could not be kept up and that there were mistakes being made. Many expressed fear of a major accident. One of the more telling findings was that the majority interviewed felt that there should be some restriction to controller working hours. Most expressed this in terms of the number of consecutive days worked (presently set a nine by the collective agreement). The majority of those who expressed an opinion indicated that they would like to see a reduction to 7 or 8 days of maximum consecutive days worked. The concept of setting a monthly limit in terms of hours, as is done for pilots, was also mentioned. It should be noted that these opinions came from controllers who admitted that they liked the overtime pay and volunteered for it. They also felt that what they were doing was reducing their longevity as controllers and leading to early burnout.

Many controllers stated that it was their intention to earn as much money as possible and retire as soon as they were eligible. When asked about stress, most controllers related it directly to fatigue and the amount of overtime that they were working. Some controllers claimed that there is a direct relationship between overtime worked and the amount of sick leave taken. However, this Special Investigation did not analyse any data to evaluate this allegation.

9.8 FATIGUE

The subject of fatigue has been widely studied, and considerable controversy surrounds the impact of fatigue on human performance. Indeed, during the file review phase, it became evident that few of the investigations into losses of separation occurrences systematically evaluated the conditions conducive to fatigue. Hence, fatigue was assigned as a contributory factor in only four of the 217 incidents. Nevertheless, the Special Investigators believe that many of the controller errors in planning, judgement, attention etc. were made under conditions of fatigue.

Whereas the demands of a pilot's workload tend to be highest for the take-off and landing phases, a controller's workload in a busy sector can require high physical and mental reactions for hours at a time. The staffing shortages discussed in Chapter 5 can exacerbate these effects. According to Weston,[4] the medical and human factors advice available suggests that a fatigue-break of 30 minutes every two hours is the minimum acceptable for a busy radar position. Indeed, assigning workload so as to provide adequate relief breaks for controllers is a principal preoccupation of supervisors.

In 1979, after a meeting of experts on ATC called in Geneva, the International Labour Office issued a list of conclusions on a wide range of factors affecting the employment of controllers. The following are noteworthy:

> 18. Controllers are directly involved in the safety of civil aviation and have problems which are unique to their profession, and their concern with safety could broadly be compared with that of pilots'.
>
> 19. Hours of work, length of shifts, duration of uninterrupted work at ATC positions and other parameters of work schedules have a direct impact on air safety. It is therefore necessary to establish guidelines for work schedules to reduce fatigue of ATClers.

> 20. Long working hours and inadequate rest periods for controllers are potential threats to the safety of aviation ...
>
> 21. Maximum working hours per day, per week and per month with minimum rest periods should be laid down for controllers by the Governments of all states in consultation with the Trade Unions and other representatives organisations concerned. These should preferably be enforceable by law ...

Following is an example of an occurrence where fatigue was found to have been a contributing factor:

> On 25 June 1989 a DC-10 descending to 6,000 feet en route to Mirabel came into conflict with a Swearingen 4 on departure from Dorval. The Departure Controller had cleared the SW4 to climb through the DC-10's assigned altitude of 6,000 feet without normal time or space separation. The Fact Finding Board was of the view that the Departure Controller was fatigued after 10 1/2 hours of duty and that he had been placed in a situation requiring constant attention. His loss of concentration was probably related to fatigue.

While the need for regulating controllers' work and rest periods has long been recognized, it is believed that some of the underlying reasons have been largely overlooked. There has been considerable research on the effects of circadian disrhythmia on pilot's performance. Indeed at the direction of the U.S. Congress, the NASA AMES Research Centre has completed a series of studies involving flight crews in both international and short-haul flight operations. The literature on the effects of circadian disrhythmia on ATClers is less well documented. Nevertheless it is believed that, just as eastbound flights have the most adverse effects on long-haul pilots, "quick changes" in shift patterns are most disruptive to controllers' natural body cycles.

Basic research shows that human beings naturally have a circadian low in their physiological cycles some time in the very early morning. During such lows, performance can be seriously affected. For example, it has been demonstrated that short-term memory is adversely affected during the circadian low temperature of the body. Indeed, anecdotal information received from controllers interviewed would confirm difficulties in memory of such things as coordinating with an adjacent unit during midnight shifts. For example, one Gander controller complained of repeatedly having to call back to Reykjavik to confirm an information transfer and of having to write numbers down to effect a simple addition.

Research has also demonstrated that the human being is fairly tolerant of changing workshifts but is less tolerant of changing sleep cycles. In particular, working a midnight shift seems to maximize the circadian disruption to normal body cycles. The 2-2-1 shift rotation inherently minimizes the adverse effects of the midnight shift by placing it last in the cycle. In principle, the controller coming off 2-2-1 shift cycle has four days in which to recuperate from the circadian disruption of the midnight shift. However, as discussed earlier in this chapter, the four daysoff become a major source of concern when overtime workload is added to the equation. In addition to inadequate recovery time from the midnight shift, additional midnight shifts will only exacerbate the body cycle disruption already experienced. (Even if additional overtime shifts are not taken during days-off, personal lifestyle factors can also exacerbate the fatiguing effects of the rotating shift cycle.)

Some controllers spoke of difficulties in getting to sleep following a midnight shift. Indeed, notwithstanding the fatigue level, research has shown that ability to fall asleep is related to the circadian rhythm of the body, rather than to the number of hours already awake. Hence, regardless of the controller's desire to get sleep following a night shift, he may have difficulty sleeping for a useful period of time. These effects can be aggravated by the normal noise and rhythm of family and household affairs.

Research has also shown that the normal body cycle is somewhat longer than the 24-hour day. Consequently, even after working five normal straight days, the average human being has accumulated a sleep deficit by the weekend. In the absence of definitive research, the investigators wonder about the effects of such sleep deficits among controllers. Given the body cycle disruptions which are an inherent aspect of the 2-2-1 shift rotation, coupled with overtime, controllers' physiological cycles must be in a constant state of flux. Indeed, it is believed that the controllers at today's busy Centres would be an ideal target population for some basic research with respect to the adverse effects of circadian disrhythmia, sleep deficits, etc. on job performance.

Perhaps the whole discussion on shiftwork, overtime, fatigue and circadian disrhythmia can best be summarized by the following excerpt from a recent FAA study[12]:

> "Many studies point to performance impairment associated with desynchronosis. As mentioned previously, when body temperature is lowest, error proneNEss is greatest. This would then translate to the mid-shift period between 3:00 AM and 7:00 AM as being a critical period. However, in actual

> practice, controllers' errors do not occur in any great number here. This can probably in part be explained by low traffic during mid-shifts. ... The general statement can be made, that people experiencing desynchronosis are temporarily in a state of internal disarray. Glandular secretion rates vary and become greatest or least at inappropriate times of the day, thus rendering the person ill-equipped either to deal with crisis or to go to sleep .... In some professions, such as ATC and medicine, error free performance is the expected norm. There is evidence that such error free performance, when attained by greater than ordinary effort, occurs at a commensurately greater physiological and psychological cost, sometimes called stress."

9.9 STRESS

There is a widespread public perception that controlling air traffic is a highly stressful occupation. The term "controller burnout" is frequently heard and images of busy control centres, such as Chicago with its "pressure cooker" environment, are common in the media.

Many studies done during recent years, however, have concluded that stress has been accorded a much greater influence in ATC than can be substantiated. This does not mean that there is no stress in ATC, but that such stress may not be directly related to controlling aircraft per se. The conventional wisdom that the responsibility for hundreds of lives day-in and day-out leads to almost intolerable levels of stress is not borne out by the evidence.

According to the ICAO Manual of Civil Aviation Medicine[13] the generally pre-conceived factors thought to be stressful are not necessarily so. For example, responsibility for safety and lives was not a stressor, whereas being overloaded was. High workload was not, but boredom was. Failure of pilots or other controllers to conform to standard operating procedures was, but shiftwork was not. This would seem to confirm the findings of Thackray, mentioned earlier in this chapter, which noted the stressful aspects of vigilance tasks.

The interviews of this Special Investigation's field survey suggest that the challenge of dealing with heavy and complex traffic is one of the major satisfiers for a controller. On the other hand, evidence was heard that their shiftwork and overtime work requirements contributed to family lifestyle stressors. Having become accustomed to the extra financial compensation from long overtime hours, additional financial commitments may also be creating added stress outside the work place.

The controllers appear to relate stress to workload and fatigue. (Fatigue in this context appears to be a direct result of overtime, while workload is related to traffic volume and complexity.) Some controllers felt that as traffic increases they are being asked to do too much, particularly in some Toronto ACC Specialties. They pointed to the U.S. system where controllers tend to be more specialized and tasks tend to be divided into more manageable segments. This does not mean more and smaller sectors, but rather a division of responsibilities within a sector.

To some degree there is evidence of a sense of frustration caused by the many factors usually associated with morale. Career limitations, labour-management relations, perceptions of a lack of appreciation or understanding by management, all contribute to a type of stress not uncommon in many other lines of work.

In summary, there seems to be a certain amount of stress in controlling air traffic which is acceptable, but there is a point at which the integrity of the overall operation becomes threatened. It was the opinion of most of those interviewed that the system was still functioning safely, but that the current pace could not be kept up indefinitely.

9.10 AEROMEDICAL CONSIDERATIONS[14]

Air traffic controllers' psycho-physiologic and patho-physiologic responses to work were investigated in the United States under a major contract for the FAA by Dr. Robert Rose as the principal investigator. (See FAA-AM-78-39 "Air Traffic Controller Health Change Study.") Each of 416 controllers were scheduled for a complete medical history, mental status assessment, and physical examination each nine months during a 36-month period. Forty thousand individual items of information during the 2,626 man-days of on-the-job observation were recorded. Following are the findings:

a) Hypertension - the population of controllers was found to have an increased prevalence and incidence of hypertension compared to findings by other studies, regardless of the criteria applied. Controllers develop hypertension at a rate three to four times that of comparable men in other occupations. Correlating with the development of hypertension was the blood pressure response to controlling traffic. Those who develop hypertension showed blood pressure elevations during work that were greater than in those who did not develop hypertension. In addition, those with hypertension exceeded their average elevated blood pressure levels during heavy workload by an amount greater than that experienced by normo-tensives. The life shortening effect of sustained hypertension is a major concern to both the FAA and the controllers, as is the threat of medical disqualification due to the adverse effects of certain prescribed medication.

b) Mild/moderate illness - Rose and his associates found an average of 2.5 acute health change episodes in the controllers each year. Illness included upper-respiratory infections, injuries, various viral disorders, and acute gastro-intestinal upsets. This group of illnesses caused the significant adverse effect of lost days from work.

c) Peptic Ulcer - During the five examinations, a slightly increased risk of developing peptic ulcers existed in specific controllers being studied.

d) Psychologic/psychiatric factors - Half of the controllers were diagnosed as having at least one psychiatric problem; the most prevalent being a disturbance of impulse control. This was traced to inabilities to control overt anger, impulses of an anti-social nature or the use of illicit drugs. Subjective distress was experienced by 13 per cent of the controllers during the three-year period, including significant depression and anxiety. These were accompanied by disturbances in daily function, eating, and sleeping. During the three years, 20 per cent developed significant "mate-role" problems. Over 50 per cent of the controllers were classified as heavy drinkers, a level considerably higher than in the general U.S. population. It was found that the controllers who develop problems in the psychologic/psychiatric category derived a significantly lower satisfaction from their work than those who did not. They were also significantly lower in their satisfaction with co-workers and had less ability to discharge work tensions when off duty. The psychologic/psychiatric group had an increased tendency to cope with occupational stress after work by using alcohol and a decreased tendency to use other means, including exercise.

Rose and his associates found that the hypertension group, the mild/moderate illness group and the

> psychologic/psychiatric group are three distinct entities. Thirty-five of the controllers in the study developed "burnout", defined as a syndrome that includes a generalized anxiety about work accompanied by a dread of going to work. A phobia to controlling traffic develops to the extent that the afflicted individual cannot conceive of continuing work. All of the above falls in the category "subjective distress." No objective physical findings characterize the several controllers who experienced "burnout" during this study. However, a common underlying factor in those experiencing burnout was their deep belief in the phenomenon. In other words, for some persons, burnout becomes a self-fulfilling prophecy.

The foregoing findings reflect research conducted in the mid-seventies in the U.S.A. No similar research pertaining to Canadian controllers was identified in this Special Investigation. Nevertheless, the nature of these findings suggests that controllers are prone to particular types of psychological and physiological problems which are occupationally related. The potential impact of such health problems on controller performance warrants further attention.

Just as older controllers have a higher error rate in monitoring tasks, controllers report a higher incidence of problems with vision as they get older. Special correcting spectacles may be required for controllers to work with near, intermediate, and distant vision requirements. Controllers' opticians should be familiar with the working environment, particularly with regard to operating distances and ambient lighting.

9.11 ATC OCCUPATIONAL HEALTH PROGRAM

The ATC Occupational Health Program (ATCOH) was established several years ago and is in operation at all the ACCs. The program is staffed with medical doctors, nurses, and psychologists, usually on a part-time basis, and counselling is available to those who request it. In addition, educational sessions and life-style enhancement campaigns are conducted. At some Centres, substantial recreational and relaxation facilities are also provided.

Interviews with ATCOH staff indicate that there has been steady increase in stress-related complaints, usually the result of excessive overtime. Dr. Roman Jovey, a consultant physician for the Toronto ACC describes the typical patient as follows:

- 20 year controller
- feels tired but can't sleep
- working too much overtime but likes or needs the money
- no other activities in his life
- lacks balance in his life

Dr. Jovey points out that average controller age at Toronto is 46 and that older controllers find it increasingly difficult to cope. There is also a high incidence of marital problems and a sense of frustration from a labour management standpoint.

In 1987, those responsible for counselling personnel in the Montreal Area Control Centre noted that the quality of life at work for many of their personnel was deteriorating. Many personnel were complaining of tension, acute stress, interpersonal conflict, harassment, and demotivation, etc. External consultant services were solicited to conduct a study of working conditions in the Centre.[15] A questionnaire comprising nine sections on the quality of working-life was administered with 173 people responding (84.8 per cent of the Centre's staff of which 101 were ATClers). Morale was found to be dramatically low, the working climate was characterized as defiant with confrontation and dissatisfaction, the management style was characterized as difficult and autocratic, and 76.8 per cent of respondents were unhappy with their work. The dissatisfaction centred on three separate aspects: the style of management, the physical working environment, and the division of labour. The study made several recommendations for improving conditions. The Special Investigating team saw few indications of the problems cited in the 1987 study. As reported by several controllers, much of these improvements can undoubtedly be attributable to more effective management today.

9.12 PERSONAL MOTIVATION

Controllers seem to possess a unique set of skills and attributes which have been difficult to adequately qualify or quantify. This has undoubtedly exacerbated the current difficulties in finding a suitable selection or screening process for new controllers. Certainly, controllers must have exceptional skills in solving three dimensional time-space problems in real time; they must be able to assimilate and adhere to a complex matrix of prescribed procedures; they must be able to articulate clearly; and today they must have a high sense of commitment to their profession. The individual who possesses these skills must also have a robust sense of self-worth. Indeed, a controller must be largely intrinsically motivated, gaining personal satisfaction from the job itself; there is little positive reinforcement given to a controller for a job well-done. On the other hand, there is considerable negative feedback if the job is done poorly. Hopkins speculates that those who are bothered by the life and death aspects of the job soon realize it and seek other employment.

There is evidence in the interviews of a "macho" image, of a "hot-shot" controller who can handle all the traffic that the system presents to him. Tower controllers in Toronto, for instance, are proud of the fact that, prior to the implementation of the present dual airport concept, a single airport controller was moving more aircraft than is now moved by two. They also candidly admit that they had to "cut a few corners" to do it. This can also manifest itself in the taking on of additional responsibilities such as accepting hand-offs outside designated areas of responsibility or trying to provide services that are not mandated. An interesting example of this was the attitude of virtually all controllers when the subject of automated conflict alert was raised. To the non-controllers on the Investigating Team, this feature, which will be incorporated in the CAATS system, is the logical and obvious solution to most collision avoidance problems. The controllers, on the other hand, appeared to be decidedly unenthusiastic about it. In addition to expected comments about the reliability and capability of such a system were those regarding the removal from the controller of the responsibility for his "raison d'etre", the separation of aircraft.

A major problem with the "macho" syndrome is the difficulty it imposes on the new controller. Often the "hot-shot" controller has developed techniques for which he has established his own norms and procedures, and these are difficult for an inexperienced controller to emulate. The new controller is not only faced with trying to be accepted into an established group but depends on that acceptance for the quality of his instruction and thus eventual qualification. There was some evidence, particularly in the Montreal ACC, that some on-the-job-instructors are "saying" to the students "watch my superior performance" rather than coaching the student controller on how to do it. (The relationship of the student controller and the OJI is further discussed in Chapter 6, Training.)

There is also a group dynamic operating today which could be described as an informal "quality control" system. Apparently, controllers who do not measure up to the group's self-determined standard are gradually eased out by various subtle techniques, such as not covering up minor operational errors. Implicit in this self-admitted process is acceptance that the "strong" controllers routinely cover-up for each other; but they will not let a " weak" controller compromise the effectiveness of their group. The potential dangers of such a system are obvious.

The working supervisor may be caught up in this system - if he fails to measure up, or if he ever fails to report an error of his own, he may find himself in an awkward position when one of his controllers makes an error. There is no simple solution to this problem, however, the provision of "supervising" supervisors would serve both the purpose of somewhat separating supervisors from their subordinates and help ensure the application of consistent standards.

That this aspect of the controllers ethic may not necessarily be bad is summarized by David Hopkins:

> "Because many controllers find ATC intrinsically satisfying, they may forego advancements or career progression in management in order to have the satisfaction of controlling air traffic. Being in a profession, they tend to develop their own professional norms and standards. Controllers expect their colleagues to maintain acceptable, though unwritten, professional standards, and are sensitive to their colleagues' opinions of their professional competence, abilities and skills. If for any reason they come to believe that they are less proficient and safe than they once were, this leads to increased effort, anxiety, and attempts to compensate. The professional respect of one's peers is highly prized."[5]

Controllers have acquired the reputation of being difficult to manage, and the interviews confirmed that friction exists between controllers and management. On the one hand, there is a group of strong-willed people with a history of fairly militant union activity, and, on the other, there appears to have been, and in some cases still is, an autocratic management style.

The ATCOH staff indicated that their second major concern after fatigue-related problems was controller/ management communication. Controllers feel that they are not consulted about changes which directly affect them and that their opinions are not respected. This comment was not entirely borne out by interviews, and it is likely that there are valid opinions on both sides. What is apparent is that efforts must be made, particularly in this time of controller shortage, to improve relations at all levels. It is worth noting that recent efforts to improve controller/management working relations appear to have had positive results in two of the four Centres visited during this Special Investigation.

The study conducted in 1987 in the Montreal Area Control Centre examined in detail the question of quality of work-life.[15] The conclusions arrived at confirmed deep-seated morale problems in the Centre and, in particular, drew attention to the gap between controllers and management. Recommendations centred on the need to establish meaningful communications and an atmosphere of trust in the workplace. Issues pertaining to employee/management relations are addressed further in Chapter 11, Management.

9.13 VISUAL PERCEPTION

The database of this Special Investigation indicates that, in approximately 9 per cent of the reported occurrences involving IFR aircraft, the other aircraft was operating under VFR. Although this number may not seem high, the circumstances of many of the incidents give cause for concern. A typical occurrence of this nature involves a large aircraft on an IFR approach just outside a positive control zone (Class C airspace) conflicting with a light aircraft operating VFR and not in communication with the tower or terminal. A second type of occurrence, though less common, is an IFR aircraft, inside a control zone, cleared for a visual approach, which conflicts with other IFR traffic cleared for a visual approach or with VFR traffic. In both of these cases, the primary responsibility for collision avoidance rests with the pilots using the "see and be seen" principle.

An example of this type of incident occurred on 14 March 1989, at Dorval Airport:

> A Swearingen Metroliner was being vectored for an IFR arrival in visual meteorological conditions. After being cleared to descend to 3,000 feet, the pilot was cleared to follow a Fokker F-100 at his 1 o'clock position and seven nautical miles(nm) at 3,000 feet on right base for runway 24 R. The pilot advised that he could not see the F-100. After being advised that the F-100 was now at 4 o'clock and four nm, the pilot advised that he could see an aircraft at the presumed relative position; however, he could not positively identify it. The controller then gave the pilot a heading change and confirmed the F-100's position as 3 o'clock and four nm. This time the Metroliner pilot acknowledged that he had positively identified the F-100 and accepted clearance for a visual approach behind it. Shortly afterward, the arrival controller again confirmed with the Metroliner that he had visual contact with the F-100 at 2 o'clock and four nm and cleared him to change frequencies and contact Dorval Tower.
>
> Meanwhile, the F-100 pilot, who had been cleared for a visual approach behind a Boeing 727 and was now on final for runway 24R was advised of twin-engined traffic five nm on

his right and in descent for runway 24L. This traffic was, in fact, a Cessna 421 which was well below him; however, seeing the Metroliner he confirmed that he could see "the twin-engined aircraft."

The arrival controller, who was now not in contact with either aircraft, saw that the Metroliner and the F-100 were dangerously close to one another and notified the tower coordinator. At that time the Tower and the Metroliner were still not in communication with each other and the two aircraft eventually ended up at eight nm on final with the Metroliner 500 feet above the F-100.

This occurrence is still under investigation; however, it appears that the Metroliner mistakenly followed the B727 instead of the F-100.

"See and be seen" (or in the U.S.A. "see and avoid") is a time-honoured technique which has served the aviation community well over the years. With light traffic and slower aircraft, it is still reasonably effective in the VFR environment. When faster IFR traffic is involved, a number of factors must be considered, specifically:

- The mind-set of the IFR pilot that radar separation is being provided from all other traffic. This is particularly true near large airports which have control area extensions (formerly TRSAs).

- The increasing dependence of controllers on secondary radar returns with digital data tags as more and more small aircraft are equipped with transponders.

- The possibility of controllers assuming that non-Mode C returns which appear within the horizontal confines of the control area extension represent aircraft operating below the floor of Class C airspace.

- Increasingly complex arrival procedures combined with automated aircraft systems both of which tend to keep pilots' attention inside their cockpits, thus reducing look-out.

- The generally higher speeds of IFR aircraft reduce the time available for conflict recognition and evasive manoeuvres. At a relative closing speed of 310 knots, if a conflicting aircraft is seen inside two miles, it is unlikely that there is sufficient time to avoid it[16].

- As traffic densities build up, the pressure to utilize visual approaches may increase, thus placing more aircraft in a "see and be seen" situation.

It must be kept in mind that, in the majority of cases, controllers do provide IFR aircraft with advisories of known VFR traffic. However, as Captain W. Monan points out, "probably more important as a mid-air conflict causal link than any other limitation is the apparent inability (or difficulty) for the radar controller to sight and point out numerous light aircraft that are not equipped with transponder, and to do so soon enough to permit early avoidance of potentially conflicting aircraft."[17]

The primary responsibility for collision avoidance historically remains the visual acquisition of conflicting traffic by the pilots. At issue is whether it is reasonable, given the technology presently available, to entrust large numbers of lives to a system which depends to such a large extent on the human eye and all its natural limitations.

9.14 OBSERVATIONS

1. Human performance factors are cited as causal or contributory in the majority of ATC occurrences.
2. Recent initiatives in the U.S.A. in the field of human factors study should yield increased knowledge in this area.
3. Controlling air traffic imposes similar, if not greater, mental workloads as piloting an aircraft.
4. Vigilance tasks are fatiguing, even when workload is light. Older controllers in particular have been found to be more susceptible to vigilance errors in scanning tasks than younger controllers.
5. Man does not perform passive monitoring tasks well.
6. Lack of supervision, and hence controller discipline, can lead to errors of inattention and lack of vigilance.
7. Light workload can lead to occurrences caused by inattention and boredom.
8. The various shift systems in use probably reflect the best compromise between rest requirements and controller acceptance.

9. Some controllers are being allowed to work an excessive amount of overtime.

10. The existing limits regarding consecutive days of work imposed by the collective agreement are not being enforced in a way so as to minimize the adverse effects of fatigue.

11. The present rates of overtime pay encourage controllers to work excessive amounts of overtime during their needed days off.

12. Fatigue caused by excessive overtime is a major cause of stress in controllers.

13. Workload and complexity is increasing to the point where some controllers are having difficulty coping.

14. Controllers studied in the U. S. A. exhibited a higher than normal incidence of stress-related illnesses.

15. The incidence of stress-related complaints for Canadian controllers has been increasing.

16. Without adequate supervision, some controllers have developed their own ad hoc methods and standards. In addition to presenting a possible safety hazard, this practice can adversely affect the training of new controllers.

17. The integration of supervisors into the workforce makes it difficult for supervisors to exercise their disciplinary and quality control functions.

18. Poor controller/management relations are contributing to stress in controllers.

19. The "see and be seen" principle as a primary means of collision avoidance should not be relied upon in high density airspace.

LIST OF REFERENCES

1. Profile of Operational Errors in the National Airspace System, 1987, U.S. DOT/FAA Office of Aviation Safety.

2. Kantowitz and Casper, Human Factors in Aviation edited by Earl L. Wiener and David C. Nagel, Academic Press 1988.

3. Hopkins, David D., "Human Factors Implications of Progressive Air Traffic Control Automation", Fourth Symposium on Aviation Psychology, Ohio State University, 198_.

4. Weston, R. C. W., "Human Factors and Air Traffic Control", appearing in Pilot Error, The Human Factors, Second Edition edited by Ronald Hurst and Leslie R. Hurst, Granada, 1976.

5. Hopkins, David V., Human Factors in Air Traffic Control, AGARDograph, N. 275, 1982.

6. Warm, Joel, S., and Dember, William, N., "Awake at the Switch", Psychology Today, April 1986.

7. Thackray, Richard, I., and Touchstone, Mark, R., "Age-related Differences in Complex Monitoring Performance", FAA-AM-81-12, April 1981.

8. Schroeder, David, J., "The Loss of Prescribed Separation Between Aircraft: How Does It Occur?", Civil Aeromedical Institute, FAA, 821432.

9. Melton, Smith et al., Stress in Air Traffic Controllers: Comparison of Two Air Route Traffic Control Centers on Different Shift Rotation Patterns, FAA-AM-75-7, 1975.

10. Hopkins, David, V., Human Factors in Air Traffic Control, AGARDograph, No. 275, 1982.

11. Hopkins, David, V., Human Factors in Air Traffic Control, AGARDograph, No. 275, 1982.

12. DOT/FAA/AM-86/2 " Biological Rhythms and Rotating Shift Work: Some Considerations For Air Traffic Controllers and Managers", January 1986.

13. ICAO "Manual of Civil Aviation Medicine", Document 8984-AN/895, Second Edition 1985.

14. Mohler, Stanley R. MD., "The Human Element in Air Traffic Control, Aeromedical Aspects, Problems and Prescriptions", International Journal of Aviation Safety, Volume 1, Issue #3.

15. Bernier, Diane et Luc, Edith "La qualité de la vie au travail au centre régional de contrôle aérien de Montréal Ministère des transports", juin 1987.

16. Distance - Speed - Time Chart, FAA Advisory Circular 90-48C, 1987.

17. Monan, Captain W. P., "Human Factors and Air Carrier Operations: Knowledge of the Limitation of the ATC System in Conflict Avoidance Capabilities", NASA Technical Memorandum 81197.

CHAPTER 10

INFORMATION TRANSFER

10.1 GENERAL

In its report on a Special Investigation into the Risk of Collisions Involving Aircraft on or near the Ground at Canadian Civil Airports[1], in 1986 the Canadian Aviation Safety Board addressed a broad range of issues pertaining to the criticality of effective information transfer in collision avoidance. In that report, the CASB stated:

> "The air traffic control system may be thought of as an information management system in which nearly all of the information changes rapidly over short periods of time. Coordinating with each other, air traffic controllers must direct and provide advisory services to pilots and vehicle operators. The exchange of information between controllers and pilots is carried out almost exclusively by means of radio telephone. Voice messages carry virtually all clearance, advisory, and warning information from air traffic controllers to pilots and vehicle operators. Unfortunately, these voice radio procedures are conducted in much the same manner as they were 50 years ago. Notwithstanding the technical advances and the quality of radio equipment, the effectiveness of the radio communication process remains hampered by the same age-old human performance variables. Since verbal communications remains an imperfect method of information transfer the requisite separation for collision avoidance is easily jeopardized."

A 1981 NASA Study[2] found that, during the period 1976 to 1981, problems in the transfer of information within the aviation system were noted in over 70 per cent of 28,000 reports submitted by pilots and air traffic controllers to the NASA Aviation Safety Reporting System (ASRS). These problems were related primarily to voice communications. The editors of that study found that:

> "Over one third of these problems involved the absence of information transfer in situations in which in the opinion of the analyst the transfer of the information could have prevented a potentially hazardous occurrence. In another third, information transfer took place, but it was a judged incomplete or inadequate, leading in many cases to incorrect actions in flying or controlling aircraft. One eighth of the reports involved information transfer that was correct

> but untimely (usually too late to be of assistance) in forestalling a potentially hazardous chain of events."

That study concluded that:

> "Both human attributes (distraction, forgetting, failure to monitor, non-standard procedures, and phraseology and complacency) and system factors (non-availability of traffic information, degraded information, ambiguous procedures, environmental factors, high workload, and less commonly equipment failure) contribute to information transfer deficiencies. The air traffic controller plays a pivotal role in information transfer within the aviation system ...."

In 197 of the 362 Fact Finding Board reports included in the data base of this Special Investigation, a contributory cause factor relating to "communications" was assigned, as shown in Table 10-1 below.

Table 10-1 Communications Contributory Factors

Incorrect/Unclear Phraseology	17
Failure to Acknowledge or Verify	19
Inadequate Coordination	77
Inadequate Sector Briefing	17
Transposition Error	8
Incorrect Radar Hand-off	3
Data Posting Error	21
Data Processing Error	21
Data Not Available	4
Other - Communications	10
TOTAL	197

Inadequate coordination was assigned 77 times reflecting a failure to properly transfer information to another controller. Furthermore, while 'forgetfulness', 'constant vigilance not maintained', or 'inattention' were assigned as contributory cause factors 172 times, communications-related problems were also cited in 94 of these occurrences. For example, inadequate coordination was related to 'inattention', 'forgetfulness' or 'constant vigilance not maintained' on at least 35 occasions.

Notwithstanding the frequency of communications-related causes, these figures do not tell the whole story. The impact of breakdowns in information transfer on ATS operating irregularities is believed to be much more profound than a statistical analysis would indicate. Occurrences which are fundamentally rooted in breakdowns in information transfer are often assigned other cause-factors. For example:

> On 17 April 1989, a Cubana IL62 transited the North Atlantic westbound at Flight Level (FL)350 in accordance with a clearance provided by Prestwick. Gander Oceanic Control believed the aircraft to be at FL310 as originally flight-planned for the entire crossing. A British Airways Boeing 747, eastbound to London, was cleared to climb from FL330 to FL370 through the actual altitude of the Cubana flight.

The Transport Canada Fact Finding Board Report noted three occasions when the Gander Oceanic Controller should have detected the discrepancy in the altitude of the Cubana flight; hence, the report assigned cause-factors relating to the inattention of the Gander controller. No factors were assigned relating to communications; yet this occurrence was precipitated by the failure of the Prestwick Controller to ensure that the Gander Controller was aware of all current flight data information on the Cubana flight, including the revised altitude.

Occurrences investigated by the CASB have also highlighted several aspects of information transfer problems. For example:

> On 06 November 1988, a Boeing 737 was issued taxi instructions and take-off clearance for Runway 24R at Toronto's LBPIA. After take-off, the aircraft was instructed to turn left, bringing it into conflict with an Airbus 310, necessitating evasive action.

The CASB determined that, among other things, there was a breakdown in coordination involving six controllers, use of imprecise and misleading phraseology, deviations from unit procedures, deficiencies in the hot-line system, and excessive workload on the South Ground Controller.

In an earlier occurrence at LBPIA investigated by the CASB, several other aspects of information transfer problems were identified.

> On 14 July 1988, a Piper Aerostar on descent through 9000 feet to Toronto's LBPIA crossed approximately 200 feet in front of a Dash 8 at the same altitude on departure from LBPIA.

The CASB found inadequacies in the hot-line system within the Terminal Specialty during peak hours, a lack of awareness by the controllers of the Aerostar's limited radio frequency capabilities, and inadequate coordination by a terminal coordinator trainee.

In view of the prevalence of such information transfer problems contributing to ATS losses of separation, this chapter will examine the communications process in ATS and the common sources of communications problems in communications.

10.2 THE COMMUNICATIONS PROCESS

For the most part, information transfer is effected through voice communications on radio telephone (R/T) directly from controllers to pilots; this is known as Direct Controller/Pilot Communications (DCPC). For example, in the terminal control areas of Toronto, Vancouver and Montreal, controllers and pilots communicate directly, usually on VHF radios. DCPC works well so long as sufficient frequencies are available to minimize frequency congestion, and enough PeripherAL (PAL) stations are available to compensate for the line-of-sight limitations on VHF radio communications which limit their useful range.

However, in large regions of the Canadian north and in the Oceanic Control areas, VHF line-of-sight limitations and the absence of VHF PAL stations preclude DCPC. Hence information transfer is generally achieved through flight service stations (FSSs), often requiring the use of HF radios. Introduction of a "third party" to the communication process introduces more opportunity for missed communications.

Within an ACC the inter-controller communications process can become extremely complex. Controllers have an extensive network of "hot-lines" to adjacent control units for external coordination, an intercom system (ICCS) to effect internal coordination, an automated system (NFPDS) to generate paper data strips to record all pertinent information on each flight, and, when all else fails, the basic telephone is used. In addition, Operational Support Staff (OSS) relay pertinent flight planning information by hand to controllers. Indeed, the process of information transfer can become so complex that sometimes a special position is designated as the "coordinator." Although the "coordinators'" principal role is to help ensure a steady, balanced flow of traffic between two or more sectors, they often ensure that pertinent information gets to the right controller in a timely manner.

The remainder of this chapter focuses on some of the more common sources of breakdowns in communications, with particular emphasis on oral communications. It does not address many of the non-verbal information transfer related issues, such as adequacy of information displays (e.g., data presentations on radar, ASDE, and NACS displays); currency of basic information on OIDS, VIP, and sector binders; body language; etc.

10.3 COMMON SOURCES OF BREAKDOWN IN ORAL COMMUNICATIONS

Since the 1981 ASRS study[2], historical data has continued to accumulate in the U.S.A. such that approximately 80 per cent of the reports filed by pilots and controllers over the years 1985 to 1988 reference ineffective information transfer via verbal communications. In the U.S.A., an industry working group was formed to identify significant communications areas of concern. The working group concluded that, if each and every pilot and controller recognized the 12 areas of concern identified by the working group and took action to eliminate the occurrence of a particular problem existing in his or her verbal communications loop, the benefits would be immediate in their quest to eliminate communications breakdowns. Their awareness "call for action"[3] identified the following 12 areas of concern:

- Similar sounding alphanumerics
- Controller hearback problems
- Phraseology
- Enunciation
- Head-sets vs speakers
- Radio discipline
- Intra-cockpit communications
- Inter-controller coordination communication
- Blocked or simultaneous transmissions
- Stuck microphones
- Readback problems
- Initial radio contact.

These issues are discussed below.

Similar Sounding Alphanumerics

Given the profusion of air carriers during recent years, aircraft with similar-sounding callsigns or flight numbers frequently arrive concurrently in congested terminal areas. Flying similar types of equipment on similar route structures (often in direct competition) and operating on the same frequency, it should not be surprising that the wrong aircraft is sometimes acting upon a clearance or instruction for another aircraft.

Several reports of callsign confusion have been received through the CASB's Confidential Aviation Safety Reporting Program. Indeed, with the creation of Canadian Airlines International (with callsign "Canadian"), the term "Canadian" proliferated rapidly, with "Canadian", " Canadian Military", and "Canadian Partner" all in use. The potential for callsign confusion was exacerbated by similar sounding or even identical flight numbers; for example, Canadian Military 715 used to arrive and depart Winnipeg on Fridays at 1555 and 1625 hours; CAI's Canadian Flight 715 also arrived and departed at 1555 and 1625 hours. Consequently, the Canadian Forces altered all their callsigns from Canadian Military to CANFORCE to avoid callsign confusion.

To reduce the confusion that can arise with similar-sounding flight numbers, controllers sometimes instruct aircraft to use their civil registration letters. On 18 August 1989, a loss of separation occurred between a DC-9 and a British Aerospace Jetstream with both aircraft on arrival to LBPIA. A Transport Canada Fact Finding Board found that the causes of this loss of separation included the failure of the coordinator to ensure that the Inner Arrival position knew of the change in the callsign of the DC-9 to its civil aircraft registration, as well as the failure of the DC-9 crew to use the civil aircraft registration as instructed.

Callsign confusion due to similar-sounding flight identification is becoming a worldwide concern of pilots. Hence, since the early 1970s, organizations like the International Federation of Airline Pilots Associations (IFALPA) have been seeking methods to reduce callsign confusion. The Special Investigators witnessed a demonstration of one very simple computer program (written by a member of IFALPA) that converts current flight numbers to an alphanumeric format to be used in conjunction with the company designator for radio-telephony purposes. Because the base includes the alphabet (vice the normal 10 digits), this system would substantially reduce the statistical probability of similar-sounding callsigns/flight numbers occurring over the R/T at the same time and location - regardless of the actual flight numbers assigned by the company; i.e., the system would be transparent to all but the flight crew and ATC. Clearly, some form of regulatory control, ideally with international cooperation, is required to limit the overuse of certain words (e.g., Canadian, Express, etc.) in callsign names, as well as in the allocation of any alphanumeric suffix to be used in conjunction with the company designator.

The CASB has also noticed problems with respect to similar-sounding fix names; for example, in northern Quebec within 85 nautical miles of each other, two navigation intersections bore the respective names of BANNE and BADDY. On 20 November 1987, a loss of air traffic separation occurred between a C141 Starlifter and Lockheed 1011. Both aircraft were at FL350 in the same vicinity in northern Quebec. The similarity in the sound of the two airways intersections may have been a contributing factor in the circumstances leading to this occurrence. In the light of this occurrence and an earlier CASRP report of a similar misunderstanding, the CASB recommended that:

> The Department of Transport rename any airway fixes where phonetic similarity creates potential for confusion with a nearby fix.
>
> (CASB 88-02)

Readback/Hearback Problems

Breakdowns in effective information transfer are frequently caused by inaccurate readbacks of IFR clearances. In addition to validating the clearance or instruction, verbal readback has the benefit of reinforcing the information presented in the pilot's mind. In Canada, Air Regulation 506 requires that a clearance received by a pilot be read back to the controller. Unfortunately, when pilots are unsure of a clearance, they may read back what they wanted or expected to hear; unless the controller is particularly vigilant in actively listening to the readback, the error may go undetected.

Several controllers (particularly in Toronto and Vancouver) report sloppy pilot radio discipline in that U.S.A. pilots frequently omit their readback of clearances. Such readbacks are not required in the U.S.A. The U.S.A. Airman's Information Manual only encourages pilots to readback the 'numbers' as a means of "mutual verification".

The hearback problem refers to the inability of the listener to accurately hear and fully understand an aural message. While the problem can be related to environmental factors such as the quality of the radio communication, workload pacing factors, external noise and distractions etc., more commonly it is related to expectancy. In other words, pilots and controllers tend to hear what they expect to hear. Consequently, pilots miscopy clearances, and controllers often miss errors in the readbacks of the clearances by pilots. During the file review of this Special Investigation, 15 occurrences of controllers missing such readback errors were identified. (Of note, in another case, a pilot failed to detect an error in an altitude readback by a High-Level Data/Radar Controller.)

In a NASA study[4], Captain W. P. Monan noted that pilots repeatedly stated "So, I made an error, but I made a readback.

Why didn't the controller catch the error in my readback?" Unfortunately, pilots appear to be reluctant to question doubtful instructions they believe they have heard from the controller. Monan finds that, all too often, pilots subordinate common sense, judgement, and operational practicality to an assumption, based on a controller's silent "confirmation" of the readback. From an air traffic controller's perspective, there is an obvious irony: their mistakes consist of failures to catch and correct errors made by airmen; yet, if ATS personnel fail to detect the error, pilots assume approval - albeit a silent one.

With sectors often only manned by one controller and with supervisors often required to actively control aircraft, the opportunity for detecting errors in readbacks is significantly reduced. As one Toronto controller pointed out, controllers cannot always listen to readbacks on one-man sectors when they are interrupted by something else. Following is an example of a typical readback/hearback problem:

> On 04 March 1989, a loss of separation occurred between an HS25 and a B737, both inbound to LBPIA, when the aircraft passed each other with 400 to 500 feet of vertical spacing and no lateral spacing. The pilot of the B737 incorrectly read back a clearance of 5,000 feet vs 9,000 feet, and the arrival controller did not detect the error in the readback. (Of note, the Transport Canada Fact Finding Board Report on this occurrence noted that "In all probability, had the Arrival controller used accepted phonetics, i.e., niner versus nine, the occurrence could have been prevented.")

Phraseology

One of the frequent contributing factors to miscommunication is the use of non-standard or ambiguous phraseology by pilots and controllers. In 17 of the 362 Fact Finding Board reports in the database, incorrect/unclear phraseology was cited as a contributing factor. The actual words employed, the sequencing of the message, and the timing of the message are all critical to its understanding. Imprecise directions such as "right at the next available" (versus "exit at taxiway Charlie") can easily be misinterpreted, particularly for flight crews unfamiliar with local operating procedures.

In examining the ATC tapes following an ATS operating irregularity, Transport Canada's Fact Finding Boards frequently reveal a large number of deviations from standard phraseology during the time immediately preceding an occurrence - even though they may not be directly contributory. While many of these are minor, they reflect a sloppiness which could eventually contribute to a breakdown in effective communications. For example, abbreviating callsigns, improper phonetics, grouping of numbers, omission of the term 'flight level', incorrect pronunciation of numbers, etc. are frequently noted as deviations from the standard phraseology prescribed in MANOPs.

Cognizant of the need for standard phraseology, Transport Canada has an ongoing program for improving upon the use of the standard phraseology prescribed in the ATS Manual of Operations (MANOPS). Most controllers accept this Phraseology Improvement Program (PIP) as necessary for the maintenance of professional standards.

Enunciation

Distinct speech is essential to effective oral information transfer. This contributing factor has more to do with "how" the message is sent than "what" the message contains. It includes the articulation of the sounds, the rate of speech, and perhaps even the tone of voice.

With increasing traffic volume, frequency congestion is becoming a common problem. To compensate during peak traffic periods, controllers may be required to talk more quickly (and without interruption) than the rate at which some of the intended receivers can accurately comprehend the messages. An example of such congestion during peak periods follows:

> On 06 November 1988, an incident was precipitated by a coordination breakdown involving six controllers at Lester B. Pearson International Airport. A Boeing 737 taxied to the wrong runway and was inadvertently cleared for take-off. However, a mitigating circumstance was that in the 4 minute and 31 second segment leading up to the taxi instructions for the Boeing 737, the South Ground Controller transmitted or received 77 separate radio transmissions.

This controller was placed in a situation of having to do too much in too little time. Under such non-stop radio communications, pilots are understandably reluctant to exacerbate frequency congestion by requesting any necessary clarification.

According to Dr. A. T. Lee of the NASA AMES Research Centre, (speaking at the SAE's Conference on Human Error Avoidance in September 1989), there are natural limits in the human processing speed for speech, due to short-term memory capacity and interference of similar-sounding information in recall. (e.g., alphanumerics). While normal conversation is at approximately 140 words per minute, Dr. Lee has noted speech rates of 300 words per minute in A. TRACONs - speech that is very compact in terms of its alphanumeric information-bearing elements.

Differences in personal accent can also lead to misinterpretations, particularly for foreign carriers whose mother tongue may not be English or French. The effects of high rates of speech and individual accents can be exacerbated by similar-sounding words or alphanumerics.

Several controllers in Gander commented on language problems encountered by East Bloc flight crews, requiring time-consuming repeats of airport and weather information. Worse still, lack of comprehension of the English language can contribute directly to loss of separation occurrences. For example:

> On 10 December 1988, the pilot of an Ilyushin IL62M misinterpreted a clearance issued to another flight and descended without authorization from FL 350 to FL 310 creating a loss of separation situation with two other aircraft over the Atlantic Ocean. A subsequent telephone conversation between the captain of the IL62M and the Gander Shift Manager confirmed the captain's poor command of the English language. (Of note, this Cubana Airline's captain has been involved in three separate occurrences in the past two years in Canadian-controlled airspace.)

Head-sets vs Speakers

The controversy over the use of head-sets vs speakers has been a long one. But the record is clear. Both pilots and controllers miss communications when listening-out on the speakers mode because of background noise or distractions. The field survey interviews with controllers reflected wide-spread dissatisfaction with the quality of the head-sets currently in use. Some complained of requiring an extra hand to hold the head-set tight to the ear; others complained of an incompatibility between the volume settings for speakers and head-sets making it difficult to switch from one to the other. Some controllers remarked upon higher standards of professional discipline when head-sets are worn; for example there is a greater tendency to use internal communications systems for coordination than to shout across the room when using head-sets, and there is a lower tendency towards engaging in idle side-chatter with colleagues during quiet periods when wearing head-sets. The enhanced professional discipline that accompanies the wearing of head-sets should reduce the risk of breakdowns in communication.

Radio Telephony (R/T) Discipline

Sloppy R/T discipline frequently contributes to poor information transfer. This issue covers a host of problems, including many of those mentioned elsewhere in this section such as poor enunciation of words, use of abbreviated callsigns, use of non-standard phraseology - or worse still, slang. It also includes such common practices as keying the microphone without an adequate period of listening-out to ensure that the frequency is not already occupied, thereby blocking others' transmissions. In addition, poor R/T discipline includes engaging a microphone before having thought out a precise message; extraneous verbiage and superfluous remarks exacerbate frequency congestion. Finally, when pilots or controllers begin to speak before engaging the radio transmitter, clipped transmissions result; unfortunately the portion of the transmission that is missing is often the callsign. Hence, a frequent complaint is that the addressee never registered the message.

Intra-cockpit Communications

Inadequate communications and crew coordination on the flight deck can contribute to misunderstood clearances. Because the Fact Finding Board process does not interview the pilots concerned and due to a low participation rate by pilots of multi-crewed aircraft in Canada in the CASRP, this Special Investigation found little direct evidence of this communication problem in Canada. Nevertheless, in the U.S.A., a total lack of communication between cockpit crew members was cited as a factor in 12 per cent of the ASRS reports...

> "In a number of reports, communications between cockpit crew members were deficient as a result of over-confidence and complacency - assumptions that everybody understood what was taking place when in reality they did not. In several reports, a lack of confidence in subordinate crew members caused captains to become overloaded by trying to do too much. Over 15 per cent of the reports dealt with information which was believed by one or more crew members to have been transferred, but for one reason or another was not."[4]

Just as controllers can be distracted, cockpit crews can miss essential flight information and clearances when engaged in extraneous conversation with other crew members or when personality conflicts become a barrier to effective interpersonal communications.

Inter-controller Coordination Communication

Of the 362 Fact Finding Board reports on file, inadequate coordination was cited in 77 cases. Indeed, coordination with other controllers, both inside and outside the unit, and with pilots is a critical element in effective air traffic control. Where procedures are well established and followed (such as hand-offs from en route to arrival controllers) coordination requirements may be minimal. But in control towers at large airports where there is a complex mix of VFR and IFR traffic (such as Vancouver), the coordination requirements can be very heavy.

As mentioned in Chapter 4 Equipment, JETS does not have the capability for automatic hand-off from one facility to another. For example, whereas controllers can internally hand-off aircraft from their radar scope to another controller within the centre, controllers in Toronto must manually handoff aircraft flying into Montreal's adjacent airspace. Given today's high traffic volume, such coordination requirements significantly increase controller workload. CAR Recommendation 2.2.1.28 sought a "radar hand-off" capability not requiring controller-controller voice communications between ATC units. The current CAR implementation plan accepts this Recommendation for implementation by the end of 1992. Given the frequency of breakdowns in inter-controller coordination, an accelerated implementation of such an automatic hand-off capability is warranted.

In addition to automated coordination between controllers, coordination can take the form of oral communication - either electronically or across the room, through appropriate strip marking, by physically pointing out a target or with other body language as a head-nod or thumbs-up. When controllers are working in close quarters, "shoulder to shoulder" coordination is often effected. But some controllers pointed out in interviews that coordination by hand gestures or orally is not recorded (and therefore is not available when occurrences are being investigated). Furthermore, shouting across the room (as was reported in the Toronto Terminal Specialty) is distracting to other controllers. One controller commented on a lack of standardization with respect to coordination requirements and training; on the other hand, several controllers pointed out that coordination requirements have been reduced through improved procedures.

Since the CASB's 1985 public inquiry into the Risk of Collisions Involving Aircraft on or near the Ground at Canadian Civil Airports[1], the Civil Aviation Daily Occurrence Reporting System (CADORS) continues to receive reports of incidents with a risk of ground collision whereby an aircraft or vehicle was cleared onto an active runway because of inadequate coordination between the ground controller and the airport controller, or between airport controllers. For example:

> On 14 February 1989, B737 was cleared to land on Runway 24L at Montreal, with a DC-9 already in position for take-off on the runway. The B737 was instructed to execute a missed approach. The Transport Canada Fact Finding Board Report found that the 1st airport controller had failed to inform the 2nd airport controller that the DC-9 was on the runway.

> (The noise level created by the more than 10 people in the tower may have "disrupted the debriefing to the point where vital information could have been missed or misunderstood.")

Inter-controller coordination requirements are particularly acute during sector briefings when a relieving controller assumes a position or when a sector is opened or closed. In the 362 Fact Finding Board reports, 17 cases of inadequate sector briefings were recorded. Current staff shortages in Canada and the resultant requirement to combine sectors or operate one-man sectors stretches the system to the bounds of human capacity more frequently than ever before. Following is a finding from a Fact Finding Board involving a Boeing 727 and a Cessna 500 at FL330 approaching Lumsden, Saskatchewan on a converging course on 04 May 1989:

> "During the period of time surrounding the occurrence several closings and openings of control positions took place at the Lumsden sector. Comprehensive position/sector briefings did not take place which, if they had, may have brought the confliction to the attention of those involved in the occurrence."

In NASA Technical Paper # 1875[2], Ralph L. Grayson studied a sample of 200 occurrences where there was a failure in ATC coordination. He categorized six human errors associated with controller coordination failures:

a) Non-recall - failure to retain information received that bears on present or future traffic situations. (Forgetfulness was cited as contributory, in 30 of the 362 Fact Finding Board files in this Special Investigation);

b) Technique error - use of unauthorized or incorrectly chosen procedures in the formulation or execution of a coordination plan;

c) Perceptual error - use of incorrect or incomplete data received from an external source, (aurally or visually) as a basis for decision-making;

d) Failure to Monitor - failure to check sources of information in a routine and timely manner.

e) Message Inaccuracy - contents of a message are interpreted differently from originator's intent; and

f) Misidentification - location or other pertinent data applicable to one aircraft utilized for another aircraft.

Grayson went on to identify nine predisposing factors, contributing to breakdowns in effective inter-controller coordination. These included:

a) Distraction - an influence or activity that diverts an individual's attention from his normal responsibility. (Distraction was cited in only 13 of the 362 Fact Finding Board reports in this Special Investigation; however, of the 35 examples of "attention - coordination" errors cited earlier, many may have been indirectly attributable to distraction, even though not so annotated by the Fact Finding Board);

b) Excess workload - traffic situation and surrounding circumstances such that the capacity of available human and system resources to respond to requirements is insufficient.

c) Experience/Training Level - inadequate individual experience or level of training is a factor in the choice of an inappropriate action or in the improper execution of an appropriate action;

d) Complacency - self-satisfaction which may result in impaired vigilance based on an unjustified assumption of a satisfactory system state. (This is more likely to occur during periods of low to moderate workload as evidenced by the Fact Finding Board Reports reviewed);

e) Airspace Configuration - boundaries of controllers' designated jurisdiction airspace are so designed that they contribute to excessive coordination requirements or to failure in the conduct of coordination. (Concerns were expressed during the field survey of this Special Investigation about the airspace configuration, and hence the coordination requirements at 60°N 60°W where Reykjavik. Edmonton, Montreal, and Gander Oceanic airspace converges.)

f) Procedural Problem - a coordination or separation procedure that induces controller error because of complexity, cumbersomeness, or unfamiliarity due to infrequent usage;

g) Automation Mind-Set - controller's unfamiliarity with procedures used under system degraded conditions when automation features normally in use are unavailable because of equipment or software failures;

h) Equipment Failure - conditions resulting from hardware failures that have an adverse effect on information available or on communications facilities. (While equipment-related problems are specifically addressed in Chapter 4, several controllers cited problems with their head-sets, frequency availability and backups, and the availability of direct access through hot-lines (vs the cumbersome process of conventional telephones) - all of which could delay or impair the inter-controller coordination process); and

j) Interpersonal Relationships - personality conflict between individuals involved in the coordination process. (When people become fatigued due to the strains of excessive overtime, tempers can become frayed and interpersonal cooperation may suffer resulting in coordination problems. One tower controller specifically attributed poor coordination between the tower and the terminal at LBPIA to personality problems).

Blocked or Simultaneous Transmissions

As traffic density increases, so does the propensity for simultaneous transmissions which result in blocked communications. On busy frequencies, it is often extremely difficult to break in to make a transmission; nevertheless, should a pilot or a controller key the microphone while someone else is talking, it invariably results in jammed receivers and creates a necessity to repeat the communications, thereby aggravating the frequency congestion. While most of the solution comes back to good R/T discipline, Special Committee 163 of the Radio Technical Commission for Aeronautics in the United States is currently drafting minimum operational performance standards for devices that will prevent ATC frequency blockage caused by simultaneous transmissions. Unfortunately, these devices are not yet readily available.

Stuck Microphones

An aircraft with a microphone stuck in the "on" or "transmit" position can create havoc for the air traffic controller by blocking information transfer with everyone else sharing that frequency. In the U.S.A. in one survey, 1,730 such incidents were reported during a six-month period, 78 per cent of which were in terminal areas.[4] The Americans found that microphones rarely become keyed by mechanical failure; rather the operators are often the direct cause of unintentional continuous keying of the microphone resulting in a prolonged blockage of the frequency for several minutes in an environment where separation of aircraft is dependent upon continuing timely communications to or from ATC. Following is a Canadian example of such a blocked frequency:

> As noted previously in this report, on 06 November 1988 at LBPIA, a series of seemingly minor operational errors, miscommunications and coordination problems resulted in a

> conflict situation two miles south of the airport between a Boeing 737 and an Airbus 310. Contributing to the circumstances leading up to this occurrence was an excessive workload on the South Ground Controller. In a 4 minute and 31 second period leading up to the occurrence the South Ground Controller made or received 77 separate verbal communications involving instructions for 15 separate aircraft on the apron. He also had to cope with a communications problem created by one aircraft with an aircraft microphone switch which was stuck in the open position.

Again, resolution of the problem is largely dependent upon good personal discipline to avoid inadvertent keying of the microphone. In the U.S.A., a minimum operational performance specification to terminate inadvertent continuous radio transmitter keying is being developed; essentially, an electro-mechanical device would terminate a transmitter's output after a prescribed period (e.g., 30 seconds). It is understood that some airlines in the U.K. and the U.S.A. are now beginning to implement such equipment.

Initial Radio Contact

Addressing errors frequently create problems in effective communications. It is hard to convey a message if you cannot get the addressee's attention. The following occurrence resulted from a simple addressing error:

> A loss of separation occurred between two Boeing 737s, on 01 April 1989 at Calgary, Alta when the arrival controller cleared one aircraft through the altitude of the second with inadequate radar separation. The controller's lack of attention to detail during the radar hand-offs of the two aircraft from Edmonton ACC resulted in him transposing the callsigns of the two aircraft.

Indeed, following two High-level losses of separation in the Montreal North sub-unit on 08 October 1988, the Fact Finding Board found that a contributing factor may have been the fact that one of the three airlines involved sometimes used a different callsign for the same (computer-stored) flight plan.

In 1983, NASA commissioned a study by Captain W. P. Monan[5] on addressee errors in communications in the United States in which several contributing factors to the callsign problem were discussed. In the study, 250 incidents of confusion involving similar aircraft callsigns (as reported to the ASRS during a four year period) were analysed. Similarities in sounds, names, letters and numbers confuse the ears, the tongues, and the minds of both airmen and controllers. The NASA study found that "similar callsigns were proliferating, as regional air carriers and air taxi services continued to displace wide-bodied aircraft with smaller transports flying multiple trips over confined, intercity route pairs."

Breakdowns in communication can occur either by pilots misperceiving a call-up or by a controller using a wrong callsign. As mentioned earlier, frequently recurring problems in this regard include similar-sounding prefix names combined with similar or identical trip numbers; or identical airline company or manufacturer prefixes combined with similar-sounding alphanumerics. For example:

> A Calgary controller pointed out to the CASB that Canadian Airlines was operating a B737, callsign Canadian 690 out of Calgary, while Air BC was operating a Dash 8, callsign Air Coach 690, out of Calgary; consequently there was considerable potential for one aircraft copying the other's clearance or the wrong aircraft squawking 'IDENT'. (It is understood that this problem has now been resolved by changing the flight numbers.)

Many addressing problems, however, derive from faulty R/T discipline. A pilot who does not clearly identify himself creates difficulties for controllers and fellow pilots alike. Some pilots and controllers have the bad habit of over-abbreviating callsigns, perhaps through over-familiarity with particular aircraft or carriers. With over-abbreviated callsigns, pilots may act upon instructions for another aircraft or controllers may issue erroneous instructions to the wrong aircraft believing it to be another with a similar-sounding abbreviated callsign.

Since a full-time listening watch to continuous ATC voice communications cannot be sustained, pilots are triggered by their own callsign. When an ATC transmission is initiated with another aircraft's callsign, the intended pilot's attention is not activated. Thus, run-on ATC messages without a break between instructions to different aircraft are particularly conducive to pilots missing their own callsign. Failure of either party to detect the error creates a false sense of security for the message originator, based upon the implicit acquiescence of silence.

10.4 COMMUNICATION PROBLEMS UNIQUE TO GANDER

The absence of Direct Controller/Pilot Communications and any means of direct surveillance throughout most of the airspace under Gander's control creates a unique set of communications problems in this Centre. Gander relies very heavily upon HF radio communications and all their attendant problems, including the need for third party involvement in the communications process. In addition, in the absence of radar coverage, surveillance of the airspace depends on pilot position reporting and an antiquated system of recording and monitoring these positions on paper flight data strips.

Following is an example of a breakdown in communications at the intermediary level of the FSS:

> On 16 July 1989, the Gander ATC controller issued a clearance through the Gander FSS for the Lockheed L1011 to climb to FL330 from FL310. The FSS specialist who took the clearance read it back correctly, then passed it to another FSS operator to issue the clearance to the aircraft; this second FSS operator issued the clearance for the aircraft to climb to FL350, bringing the L1011 into conflict with an aircraft already established at FL350 on the same track.

The Operating Irregularity Investigation Report cited several factors which may have contributed to this loss of separation:

- the clearance was not received directly from the controller by the specialist involved,
- the specialist had worked 14 shifts in the 12 days prior to the occurrence,
- the ambient noise level in the operations room was high at the time of the occurrence, and
- there is no local procedure in place for the passing of an ATC clearance from one FSS position to another FSS position.

Given the operating characteristics of HF radios, at the best of times, communications on HF are very time-consuming. Controllers reported that delays in relaying a simple message can take up to 30 minutes; routinely, position reports are received 15 to 20 minutes after the fact. Under ideal conditions, a pilot's request may be turned around in 10 minutes, but, under summer traffic conditions, 16-minute turnarounds are the norm. Even with the feature known as SELCAL, Gander apparently is unable to meet a 10-minute turn around in summer - even under emergency conditions. As a former vice-president of the International Federation of Airline Pilots Associations wrote: "A detailed plan should be developed with the object of removing HF frequencies as a medium for communication in civil aviation. It is intolerable that half the cockpit crew is busy for 15 minutes to deliver a routine message."[6]

The effectiveness of HF radio communications is seriously compromised by atmospheric conditions, sometimes requiring the controllers to increase longitudinal separation by 50 per cent to compensate for degraded position reporting; for example "sun spots" regularly degrade HF effectiveness. While such conditions can be forecast to some extent, even with 14 frequencies available, the Gander IFSS has difficulty coping with today's volume of traffic.

The FSS is reported to be handling 2,000-3,000 HF messages per day, concentrated into the few hours of the peak easterly and westerly flows. Because of the particular problems associated with HF communications, flight service specialists (formerly known as radio operators) are required to effect the necessary information transfers between controllers and pilots. Copying or typing errors occur at this intermediary level as the requisite information is recorded for onward transmission to the action addressee. Ten teletypes and a team of Operational Support Staff are then required to hand-deliver the information from the machines to the appropriate controllers. Priority is given to pilot requests which are printed on pink paper. With up to 3,000 message strips a day being processed, the resultant paper mill creates considerable potential for error.

Recognizing these difficulties, CAR Recommendations 3.1.1.5 recommended that Transport Canada eliminate excessive air-ground message delays within the Gander Oceanic Control Centre by replacing the existing paper delivery medium with an automated message delivery system to appropriate control sectors by December 1987. It is understood that an automated system for processing these strips is scheduled for implementation early in 1990; this system, known as the Gander Automated Message Processing System or GAMPS, will display the messages directly at the appropriate controller's position.

Following is an example of an occurrence whereby a gross navigation error went undetected, in part, due to problems with the pilot-controller communications process over the North Atlantic and with an antiquated system of flight-following:

> On 08 July 1987, a Lockheed L 1011 passed within less than 100 feet vertical separation of a Boeing 747, both aircraft being westbound from London to the U.S.A. The crew of the L 1011 did not perform adequate cross-checks of their INS, nor did ATC query the crew's estimated time of arrival over the next reporting point.

The CASB issued four recommendations as a consequence of this occurrence, one of which was that:

> The Department of Transport take immediate steps to provide more timely and reliable controller/pilot communications in the Gander Oceanic Control Area.
>
> CASB 89-06

Recognizing the problems in timeliness in communications, the often poor quality of HF communications, the volume of information to be transmitted vis-à-vis the workload of two-man cockpit crews, etc., a VHF ACARS (Airlines Communications Addressing and Reporting System) air-ground data link system with coverage in the southeast U.S.A. was deployed by several far-sighted American carriers in the late 1970s. The objectives of this system were to provide accurate reporting times, to reduce cockpit workload, to ensure rapid receipt of reports, and to simplify operating procedures. Today, many American carriers and Air Canada are using ACARS data link for much of their operations. Using ground-based computers and a ground-based network of VHF stations, Air Canada aircraft which are equipped with ACARS are capable of receiving their IFR Oceanic clearances automatically; a hard copy of the clearance is actually delivered to the flight crew through the on-board data-link printer.

Use of Air Ground Communications Systems (AGCS) like ACARs could go a long ways towards reducing some of the common problems associated with oral information transfer today - especially to the extent that coverage over the North Atlantic can be achieved. The ACARS data link system is currently being operated under test to develop an automatic clearance delivery and readback capability using GAATS. If successful, Transport Canada plans to extend this capability to busy Centres, like Toronto. In the future, the use of satellites to permit both VHF DCPC and expanded data link AGCS applications should further reduce current weaknesses in the information transfer process necessary for controllers. (Indeed, Teleglobe Canada has recently entered a joint venture with Belgian and Australian firms to relay messages to/from aircraft via one of three Inmarsats and a network of ground stations for both critical air traffic control data as well as passenger personal/business messages.)

10.5 OTHER COMMUNICATION PROBLEMS

The file review and field survey brought to light two other problems relating to the effective transfer of information. These are discussed below.

Timing

Workload often leads to attempted information transfers at inopportune times. The CASB's Final Report on the Risk of Collisions on or near the Ground at Canadian Civil Airports noted the problem of attempting to pass critical taxi instructions to pilots during the roll-out after landing, which is a period of intense cockpit workload. On 21 May 1989, a risk of collision between a DC-9 and a B727 occurred at Dorval, in part because the B727 flight crew missed an instruction during landing roll-out to hold short of an intersection with another active runway.

Controller workload may lead to the late transmission of critical information. On 15 December 1988, there was a loss of separation between a B737 and a Convair 580 being vectored for parallel ILS approaches at LBPIA. The arrival controller did not issue the heading to intercept the localizer in time to prevent the B737 from flying through the on-course resulting in less than the required separation.

Conversely, pilots may delay contacting a controller thereby precipitating an occurrence. On 17 June 1988, a loss of separation between a B737 and a Swearingen Metroliner was precipitated by non-compliance and other pilot errors deriving from a rushed descent; the B737 had traversed 140 miles of Toronto Centre airspace prior to contacting the Centre!

On the other hand, some controllers appear to expect an instantaneous response when they issue instructions to flight crews, who are frequently busy with other aspects of flight operations concurrently. On 18 November 1987, a loss of separation occurred between a B737 and a Beechcraft 200 approaching LBPIA. The Fact Finding Board reported that 66 seconds elapsed between the time that the radar controller instructed the Beechcraft to contact arrival and the time that the communication transfer was completed. The radar controller had assumed that a more rapid frequency change would permit the Arrival controller sufficient time to maintain the necessary separation from the B737.

Strip Writing

Just as misunderstandings between controllers can derive from problems in oral communications, problems in strip writing can lead to occurrences. Of the 362 Fact Finding Board reports, data posting errors were cited in 21 occurrences. On 24 May 1989, a loss of separation between a C130 and a B737 occurred near Kuujjuaq during a transfer of control of responsibilities when the second controller misinterpreted the information on the data strip. In this case, the Fact Finding Board identified a requirement to standardize procedures for recording estimates.

The National Flight Data Processing System (NFDPS) which has automated flight data handling and strip printing has reportedly reduced the error rate associated with hand-written information and the difficulty in ensuring a uniform script.

10.6 OBSERVATIONS

1. Communications-related problems are found to be contributory in at least half of all ATS losses of separation. Furthermore, information transfer breakdowns are believed to be contributory factors more often than assigned by Fact Finding Boards.

2. The introduction of a "third party" i.e., a radio operator, into the communication process introduces more opportunity for missed communications; hence, Direct Controller/Pilot communication should be achieved whenever possible.

3. The physical difficulties in reliability imposed by HF radio contribute to communication breakdowns.

4. The following general areas are cause for continuing concern in oral communications:

    - Similar sounding alphanumerics
    - Controller hearback problems
    - Non-standard phraseology
    - Enunciation
    - Quality of Head-sets
    - Radio Telephony discipline
    - Intra-cockpit communications
    - Inter-controller coordination
    - Blocked or simultaneous transmissions
    - Stuck microphones
    - Readback problems
    - Initial radio contact or addressing errors

5. The cumbersome system of paper-handling in the Gander ACC delays pilot-controller communications and is vulnerable to further information transfer problems. Streamlining of this message-handling process is urgently required.

6. Expanded use of data link systems and satellite-based communications systems (such as ACARS) offer considerable potential for reducing information transfer problems for transoceanic and remote northern air traffic.

7. An electronic hand-off capability could reduce the verbal coordination requirements during hand-offs between adjacent units.

8. Both pilots and controllers need to be sensitive to the other party's working environment in timing their communications.

9. Regulatory measures are probably required to reduce growing callsign confusion attributable to the proliferation of similar-sounding company identifiers and flight numbers.

LIST OF REFERENCES

1. CASB, Report on a Special Investigation Into the Risk of Collisions Involving Aircraft On or Near the Ground at Canadian Civil Airports, 1987.

2. Billings, C., and Chaney, E. S., Information Transfer Problems in the Aviation System, Technical Paper 1875, Washington; National Aeronautics and Space Administration, 1981.

3. "Aviation Industry: A Call To Action For Pilots/Controller Communications Awareness", A Joint FAA Industry Partnership to Improve Pilots/Controllers Communications, 1988

4. Monan, Captain W., Human Factors and Aviation Operations: The Hearback Problem, Contractor Report 177398, Moffet Field: National Aeronautics and Space Administration, 1986.

5. Monan, Captain W., Addressee Errors in ATC Communications: The Callsign Problem, Contractor Report 166462, Moffet Field: National Aeronautics and Space Administration, 1983.

6. Vermeulen, Captain H. M., "Radio Telephony - A Case for Growing Concern" International Journal of Aviation Safety, Vol. 3, No. 4, December 1985.

CHAPTER 11

MANAGEMENT

11.1 GENERAL

The investigation process is one of gathering and analysis of facts, always questioning "why"? The bulk of this Special Investigation has focused on individual occurrence reports and interviews with individual controllers and managers. While the majority of the occurrences investigated were precipitated by breakdowns in individual or team performance, analysis often points back to the environment in which the controllers must operate. Many aspects of this environment are influenced or controlled by management; e.g., equipment, procedures, staffing, training, etc. This chapter discusses management's role in risk of collision occurrences.

Chapters 4 through 10 of this report have identified literally dozens of safety considerations warranting managerial attention, both at the local and the national levels. This chapter focuses on broader issues, principally of concern at the national level. In particular, this chapter addresses the adequacy of national planning, the operating philosophy behind current controller workloads, employee/management relations, quality control and such safety-related programs as the Operational Condition Report program and ATC safety awareness/promotions programs. It also touches upon the role the Canadian Air Traffic Control Association (CATCA) in pursuing human and safety-related issues at the national level. Finally, the chapter examines the current process for investigating ATS occurrences by Transport Canada and the CASB.

11.2 NATIONAL PLANNING

In many respects, the quality of the current ATS system in Canada is a direct function of the quality of long-term planning executed at the national level of the Department of Transport. Transport Canada does have several coherent plans to ensure the continuing effectiveness of the Air Navigation System beyond the year 2000. For example, the Canadian Airspace Systems Plan (CASP) is a coherent, capital equipment acquisition plan for the diverse systems that comprise the Air Navigation System. There is a Flight Information Services Strategic Plan and a Canadian Aviation Weather Plan to address those aspects respectively. In addition, in 1989 for the first time, an Air Navigation Plan was published outlining Canada's radio navigation plans; it complements the Canadian Airspace Systems Plan. Furthermore, in 1985, the Canadian Airspace Review, a cooperative effort with the aviation community, was conducted resulting in 600 recommendations which in large measure are currently being implemented; these recommendations are having a direct impact on the other national plans mentioned.

11.2.1 The Canadian Airspace Systems Plan[1] (CASP)

The Department of Transport manages the Canadian Air Navigation System to provide for the safe and efficient operation of aircraft within Canadian-managed airspace. To do this, Transport Canada formulates policies and procedures governing the operation of aircraft within the airspace and on airports, and for the provision of a variety of services including aeronautical information, aviation weather, flight planning, air traffic control, flight advisory, services, as well as for the provision and operation of en route and approach navigation aids. Many complex systems are needed in the provision of these services.

Aviation has grown rapidly in spurts that have been difficult, if not impossible, to predict with confidence. Thus, systems development has not always kept up to date with user requirements and capabilities in handling North American air traffic. Canada and the United States recognized these problems in the late 1970s and, in collaboration with ICAO, developed plans for the modernization of their respective air navigation systems. Canada first published its Canadian Airspace Systems Plan in October 1983 and endeavours to update this plan biennially. The CASP contains a development and integration strategy for modernizing and improving the systems of facilities and equipment utilized in the provision of air traffic services up until the year 2000.

The CASP[1] recognizes that the current air navigation system has limited expansion capability and is difficult to adapt to changing requirements. Today's systems are characterized by:

"- high operation and maintenance costs where vacuum tube type electronic equipment is in use;

- multiplicity of leased communication lines;

- limited capacity and capability of equipment used in the air traffic control systems;

- different types of computers and software languages in each ATC sub-system;

> - different types of controller consoles and display equipment in enroute and terminal facilities;
> - inefficient air traffic data transfer;
> - highly labour intensive operations involving extensive supply, training and technical support resulting in low productivity and capacity in the air traffic services;
> - almost exclusive reliance on tactical air traffic control methods;
> - inflexible route structure design;
> - no systems integration and no inter-facility data acquisition and transfer;
> - diminishing runway capacity at some major airports and a limited capacity to predict air traffic congestion and the subsequent need for flow management;
> - inability to meet the demand for pre-flight aviation weather briefings;
> - limited access to real-time weather data.
>
> The system must be modernized to overcome its deficiencies and to meet the demand for improved services. Adding more technicians, controllers or expanding the current system in other ways will only compound its difficulties."

Although called a "plan", the contents of the CASP range from recording decisions that have been taken concerning modernization of certain components of the Canadian Air Navigation System (such as RAMP) through projects that are well advanced in the approval process (such as the CAATS). The CASP identifies five billion dollars worth of capital investments. These are required by the year 2000 to integrate technological advances in the ATS system, the flight service system, the aviation weather system, the ground to air system, the inter-facility and intra-facility communication systems, and the maintenance and support systems.

The CASP also provides forecasts as to when certain advanced technologies (e.g., satellite-based systems) can be considered as potential solutions.

CASP improvements to the Air Traffic Services Systems were described in Chapter 4 Equipment. In addition, significant improvements are planned for the ground to air systems including the communication systems, en route and landing navigation systems and surveillance systems. For example:

> "Communications improvements focusing on replacing obsolete vacuum tube-type equipment with solid state technology have virtually been completed. Additional communication facilities will be provided, particularly in northern areas. Installation of remote maintenance monitoring for communications systems and conversion of communications equipment to 25 kHz channel spacing capability will be completed. High frequency (HF) communication facilities will be converted to solid state. Total VHF communication coverage at 12,500 feet and above in the high density traffic area will be completed. Consolidation of compatible communications, navigation and radar equipment into common buildings will be carried out where costs savings and improved reliability can be achieved.
>
> Navigation systems developments will see the completion of a VOR-DME network which will ensure that navigational coverage is consistent with the coverage provided by surveillance radars in the high density traffic area.
>
> "Area Navigation Task Force" studies will continue to determine if VLF coverage should be implemented to supplement Omega in North and Central Canada. The concept of required navigation performance capability for operations at and above 18,000 feet in the low density traffic area will be adopted. Increased use of NAVSTAR (GPS) can be expected as the satellites become operational and civil avionics become less expensive.
>
> Landing Systems Development will see the implementation of MLS at qualifying airports by the year 2000. Withdrawal of the Instrument Landing System (ILS) will begin at International Airports on or about Jan. 1, 1998. Dependent upon domestic requirements or international agreements withdrawal of ILS could occur as early as Jan 1, 1995. Implementation of category III operations at a small number of the busier airports is expected by year 2000.
>
> Surveillance systems development will see the replacement of all existing radar systems, both primary and secondary, and the incorporation of SSR Mode S data link in the enroute secondary surveillance radars.
>
> Coverage by these systems will be provided in the high density traffic area at and above 18,000 feet and in

> heavily utilized areas at and above 12,500 feet. Below these altitudes coverage will be available in terminal control areas. In low density traffic areas, at and above 18,000 feet surveillance will be provided by relaying airborne derived navigational information via a satellite/HF data link.
>
> The weather surveillance data provided by the primary ATC radar will be combined with the AES weather radar network, which will include three DND radars, will improve the real-time weather picture for pilots, controllers and fight service specialists."[1]

The Canadian Airspace Systems Plan is ambitious and expensive. Yet, given the shortfalls in the Canadian Air Navigation System identified in the CASP, and given the increasing demand for air travel, in many cases the required enhancements to ATC capabilities are already long overdue. For example, as already discussed in Chapter 4 Equipment, given today's transoceanic traffic, a satellite-based surveillance and communication system is required now. Slippages in program implementation due to technological or funding barriers could have serious consequences for the safety of air travel.

11.2.2 Canadian Airspace Review (CAR)

In 1985, Transport Canada undertook a Canadian Airspace Review (CAR) in cooperation with representatives of the aviation community. CAR was charged with the responsibility to comprehensively review the current air navigation system procedures, flight regulations, and airspace structure with the purpose of validating the current system or identifying changes which would improve it. While the CASP outlines a proposed technical framework to resolve equipment problems with the air navigation system, the CAR sets out an operational framework to address other problems with the system.

Twenty-five separate task groups with representation from the Canadian aviation community met with officials of Transport Canada to examine particular facets of the air navigation system. Together, they made 600 recommendations of which 20 were referrals to other task groups, 29 were combined with other virtually identical recommendations and 14 were not adopted. Transport Canada's current Implementation Plan[2] contains 537 recommendations as broken out in Table 11-1.

Table 11-1 CAR Recommendations

The Terminal System		
- Airports	22	
- Facilities	22	
- Radar Services	02	
TOTAL		46
The Enroute System		
- Navigation Systems	68	
- Fixed Routes	15	
- Random Routes	09	
- Flow Management	08	
TOTAL		100
Flight Service System		
- Charts and Publications	62	
- Weather	47	
- Flight Information	13	
- Flight Service Stations	07	
TOTAL		129
Airspace Systems Structure		
- Airspace Classification	28	
- Mountain Flying	02	
- International Interface	39	
- Southern, Northern and Arctic Control Areas	03	
TOTAL		72
Policies, Regulations, Standards, and Procedures Overview		
- Documentation	79	
- Regulations	29	
- ATC Manual of Operations	51	
- Separation Minima	31	
TOTAL		190
TOTAL		537

Of the 537 recommendations, Transport Canada reports that it has implemented or is planning to implement appropriate action for the majority. In 122 cases, implementation action has been delayed, in 20 cases action is pending, and in nine cases no implementation date has been established. An outside contractor performs verification and validation of each implemented recommendation to ensure it meets the original intent.

The Canadian Airspace Review is a highly commendable initiative. The consultative process with the aviation industry has resulted in a series of realistic recommendations touching on most aspects of Canadian air operations. Timely implementation of the recommendations of the CAR will go a long ways towards redressing many of the deficiencies confirmed through the conduct of this Special Investigation.

11.3 STAFF PLANNING

The most significant shortcoming in Transport Canada's national planning for the provision of Air Traffic Services is in the area of staffing. As discussed in Chapter 5, Staffing and Workload, economic conditions and several government initiatives have converged to create the current staffing crisis.

The Resource Alignment Project found that productivity gains had been such that the then current allocation of operating IFR controllers was approximately 150 PYs in excess of 1982 operational requirements. At about the same time, approximately 130 controller positions were found to be surplus when it was decided that supervisors must be qualified and available to perform controller duties. In FY 83/84, an A Base Review Team found an additional surplus of controller PYs, particularly in airport control towers, due in large part to a dramatic slowdown in VFR activity levels. In 1985, in accordance with the government's policy to "downsize", a further 182 positions within ATS were earmarked for elimination, most of these being non-operational specialists.

At the same time, the ATS Branch was forecasting growth for 1988 and therefore was recommending restarting ab initio training in FY 85/86. However, due to internal differences of opinion, this training was not started until June 1987.

The consequent staffing shortages have been exacerbated by the traffic growth which resulted from the government's policy on economic regulatory reform in transportation, higher than forecast attrition rates in training, higher than forecast retirement rates, etc. In sum, it would appear that "the big picture" was lost at the highest levels of senior management in Transport Canada with respect to ATS staffing requirements during the period 1984 to 1987. The conflicting objectives of downsizing in government and accommodating growing traffic levels have not been satisfactorily reconciled.

Transport Canada does not appear to be taking a coherent, system-wide approach to long-range staffing requirements for the ATS branch. While Transport Canada does have a National Staffing Plan with a get-well date of 1994, this plan may be overly optimistic. Even if it is accurate, four more years of operations under the current crisis will most likely result in continued high workloads, continued operating irregularities compromising safety, and increasing morale problems which will likely result in early retirement of controllers, etc. Higher than forecast activity levels would only exacerbate this situation.

To some extent, Transport Canada appears to be placing excessive reliance on technological gains to meet increasing operational demands, rather than pursuing parallel people-oriented programs for improving controller productivity. For example, according to the CASP:

> "Against a projected doubling in traffic growth by the year 2000, modernization of the ATC system, principally through the comprehensive use of automation provided by CAATS, will ensure little or no growth in the number of air traffic controllers compared with the present growth rates without automation. However, the implementation of CAATS will result in a significant increase in productivity."

Major initiatives beyond those outlined in Chapter 5, Staffing and Workload, are required. Indeed, a major departure from traditional thinking may be required to bridge the gap to the forecast get-well date. For example, while Transport Canada has considered the idea of reallocation of resources, there does not appear to have been any significant initiative in this direction. As pointed out in Chapter 2, except for the "top 10" towered airports, total traffic remains approximately 9 per cent below the 1980 level. This suggests that some rationalization of tower resources may be possible. According to Transport Canada's calculations,[3] "six airports satisfied the benefit/cost criteria for airport control service discontinuance." These six airports (Waterloo/Wellington, Sydney, St. Catharines, St. Jean, Brandon, and Castlegar) have an establishment of 41 qualified air traffic controllers, with a strength of 37 (Sep 89). Given that the current traffic at these airports does not justify continued staffing of these towers, and given the lowered level of activity at most other towered airports, consideration should be given to developing plans for the most effective reallocation of this scarce resource.

According to the Director of Air Traffic Services:

> "We have asked controllers across Canada, especially from units that are at full complement, to relocate to Toronto. There were no volunteers, probably due to the cost of living in the Toronto area, especially housing costs."

It is understood that controllers from the six under-utilized airport towers may not be qualified or suitable for duties in the busiest towers or centres. It is, nevertheless, suggested that these controllers could be relocated to busier towers, which in turn might liberate controllers who are more suited to work in the high density areas. In any event, if monetary considerations are the over-riding factor, consideration must be given to finding suitable incentives to make voluntary relocation attractive. Given the high cost of training ab initio students and developing them to a level of competence suitable for the busiest centres and towers, such cash incentives would likely be a bargain, even if in the six-figure range.

As discussed in Chapter 6, Training, current staffing shortages are being exacerbated by a lengthy recruiting, selection, and training program and by an inordinately high attrition rate during that training period. Again, tinkering with the tried and tested methods will not likely suffice in producing sufficient qualified controllers soon enough to meet operational requirements. In the short-term, streaming in basic training and specialization at particular sectors and the unit level should be examined. For the longer term, the entire philosophy of training and development of controllers for their entire career requires reassessment. Few other occupations expect the newly qualified employee to cope at the highest workload levels on the most complex tasks at all positions within the team from the first day following licensing.

Unless there is a radical departure from current thinking in staffing with the application of innovative ideas, the current staffing initiatives being taken by Transport Canada are not likely to resolve current staffing shortages in time to maintain a satisfactory level of safe operations.

11.4 PLANNING IN ATC OPERATIONS

During the file review phase of this Special Investigation, it was noted that controller planning and controller judgement were cited to be contributing factors in 88 and 75 of the 217 files reviewed, (i.e., 12.6 per cent and 10.6 per cent respectively). Consequently, in structuring the interview format for the field survey phase, Investigators attempted to probe the planning issue. However, from the controllers' perspective, little meaningful feedback was obtained. One terminal controller said that everything was so busy his responses had to be automatic, relying on instincts; i.e. there was not time for planning. Similarly, individual controllers were unable to provide meaningful feedback with respect to judgement-related issues; from their perspective, it is difficult for them to perceive shortcomings in their personal judgement until they have had an occurrence where their judgement failed them.

One of the reasons for the frequency of planning and judgement errors in the loss of separation occurrences reviewed may be fundamental to the current ATC system. As noted earlier in this chapter, present ATC systems are characterized by several shortcomings, including "almost exclusive reliance on tactical air traffic control methods." Hence, it is individual controller workload which becomes the critical factor in determining both system capacity and acceptable safety margins. As noted by J. Levesque, Director General Euro Control[4].

> "In many cases, the factor limiting traffic handling capacity is the amount of work involved for controllers, particularly for radar controllers, rather than saturation of airspace. As with growing traffic their workload has increased to unacceptable levels, the conventional expedient has been to introduce additional controllers and to subdivide the airspace accordingly. This process, however leads to a large number of small sectors, with a tendency to more frequent transfers of control, taking up a great deal of flight crew and communication channel time, and increased inter-sector coordination. The tendency is aggravated by the higher performance of modern airplanes, in that larger areas are needed to execute manoeuvres at high speed and higher speed reduces transit time in a given area. Moreover, there is a lower limit to the possible size of sectors down to which they may be reduced without disrupting the necessary ability of control sector teams independently to apply short term changes of aircraft heading or level to maintain safe separation between flights. Where that lower limit is reached - as is already the case in a few areas of high traffic density - any further reduction would be counter productive to system capacity and would also be most undesirable to flight crews, at least as long as all communications with ATC and channel changes are still "manual" activities. If ATC is to be able to handle 30% to 40% more movements in the future, other means of increasing traffic handling capacity must be sought."

Levesque goes on to state that the solution is either one of relying primarily on improved tactical radar control or a more strategic approach, comprising more efficient route structures, improved aircraft navigation performance, and deconflicting flight plans prior to flight to a greater extent than is achieved today.

In Canada, work is ongoing to produce a more efficient route structure. Defined navigation performance standards for particular airspace are ensuring that appropriately equipped aircraft can navigate with sufficient precision to keep the volume of protected airspace needed around each flight to a minimum. Performance standards have been established for RNAV flights for appropriately equipped aircraft. Task Group 2.2.1 of the Canadian Airspace Review recommended that:

> "The Transport Canada Aviation Group develop standards, criteria, and procedures to permit area navigation (RNAV) Terminal Area Operations such as: transit through, stub-runway operations, operations at airports in close proximity to each other, precision/non-precision approaches, and separate access routes."

According to the Transport Canada Implementation Plan[2], Transport Canada scheduled implementation of this Recommendation in June of 1989. And, some traffic deconfliction does take place during the flight-planning phase; for example, the Gander Automated Air Traffic System (GAATS) does deconflict flight plans for aircraft entering the Organized Track System on the North Atlantic.

The lessons learned from these precedents must be built upon with expedience in order to relieve controllers of the excessive workload created by over-reliance on tactical control.

Other means for reducing the tactical workload of controllers include improvements to current surveillance techniques. RAMP will undoubtedly result in significant improvements in the radar coverage in Canada. But beyond RAMP, the users' requirements for more direct routing and the need for closely spaced parallel tracks on certain routes will require even greater accuracy and reliability of surveillance. Mode S offers advantages in this regard as well as having an air/ground data link capability. Indeed, Transport Canada has accepted CAR Recommendation 2.2.1.19 to incorporate a Mode S capability into the Canadian airspace system subject to a benefit/cost analysis. According to J. Levesque of Euro Control:

> "The use of surveillance systems providing uninterrupted coverage over the airspace of adjacent centres should enable position reporting as well as most identification calls by radio telephony to be virtually eliminated for enroute airspace. If, by enhancing the planning element of ATC we can reduce the number of radar interventions necessary to resolve conflicts, related air-ground communications should also be reduced or at least should not increase with growing traffic. On the other hand, the need for aircraft derived information ... may well call for exploitation of the data link capability of SSR Mode S."

Such prognostications are not science fiction. At the 1989 Paris Airshow, the FAA demonstrated how flow control methods, as practised in the U.S.A, can solve high density ATC problems. To prove it, the FAA demonstrated an ATC display which showed the actual position of all transponder equipped aircraft flying across the U.S.A in real time. According to Joseph M. Del Balzo, the Executive Director for System Development of the FAA:

> "If there were no moves towards automation there would soon simply be too many aircraft and too much information for the controller to handle ... With the automated ATC concept, like we have with our AAS program, the computer can work out possible conflict alerts on the new course 5, 30, 40 minutes in advance. It will then tell the controller all the possible variables and let him decide what to do, recommending the best option. ... People make decisions best, computers handle data best."[5]

Clearly, the decisions taken today to resolve Canada's ATC problems in the short term must be seen in the context of the longer term requirements and solutions. Recruiting, selecting, and training more controllers to handle an ever-increasing tactical workload may be necessary. But for the longer term, the focus should be upon reducing the controllers' tactical workload, drawing upon the technological gains of automation, such that he or she participates in the strategic decision-making process as an ATC systems manager.

11.5 EMPLOYEE/MANAGEMENT RELATIONS

A recent report to Congress by the United States General Accounting Office[6] found "a substantial difference between controllers' views of their morale and facilities managers' views of workforce morale ... suggesting a continuing communications gap between FAA facility management and the controllers - and to a certain extent, the supervisors. ... Since 1981, a vast difference has existed between the perceptions of managers and those of controllers regarding workforce morale and working conditions, representing a serious workforce problem." This, in the view of the Flight Safety Foundation (the consultant which independently evaluated the U.S.A. GAO's survey questionnaire) is a significant contributor to a "less than desirable" margin of safety.

While the CASB's Special Investigation found significant employee/management issues which could impact on safety, the communications gap in Canada does not appear to be as wide as that reported to Congress. Indeed, the Canadian survey team was generally impressed with the shared perspective of problems facing ATS today as indicated by journeymen controllers up through the various levels of supervision and management, particularly to the unit chief level.

At the national level, there were greater differences in perspective. For example, although feedback at the unit level is that many controllers are being overworked, Transport Canada management in Ottawa is "with some few exceptions, left with the abiding conviction that controllers are not overworked." In a two-day meeting with senior officials of the ATS Branch, the consensus seemed to be that, while there are shortages of controllers at some locations, most controllers receive adequate relief breaks and are not working an excessive number of days per month. Some of these officials tended to relate current working conditions to their perception of more demanding working conditions when they were young, operational controllers. Generally, they did not share the same perception with regard to current inadequacies in the provision of adequate supervision as the views expressed at the four operational units visited. Nor did they seem to acknowledge the potentially severe morale problems extant in some of the units. In summary, at the national level, there is a perception that many of today's workload, overtime, and supervisory problems are largely self-induced at the local level.

11.5.1 Employee Confidence In Management

Although the field survey did not have structured questions pertaining to ATS management, many of those interviewed gratuitously commented on management. Several controllers noted that the current staffing shortages (perhaps the most significant shortcoming in the ATS system today) originated around the time of Transport Canada's A-Base Review. Clearly, the myths and realities of the A-Base Review have left a bad taste in many controllers' mouths.

Many controllers complained about inadequacies in Transport Canada's ability to forecast. Specifically, they commented on shortcomings in forecasting selection and training requirements in order to meet required staffing levels for expected traffic volumes. Some complained about Transport Canada's inability to accurately forecast equipment and procedural requirements, given the changing traffic patterns and capabilities of the latest technology aircraft and market demands. Consequently, several controllers spoke with a sense of hopelessness, cynicism, and despair about the future. Notwithstanding the numerous

improvements being implemented, one Montreal controller remarked, "while we need more DCPC and DME now, in the year 2000 Montreal will still be controlling by paper strips and HF."

While the journeyman controller often has a clear idea of what is required for the safe fulfilment of his job, frequently he sees the bureaucracy as an insurmountable hurdle. As one controller said, "It's not the people that are occupying the positions within the bureaucracy that are the problem, it is the bureaucracy and the red tape itself." Even a shift manager complained that a relatively minor programming change can be stonewalled by the "bureaucratic pressure and usual management foot-dragging." Such perceptions suggest that an unhealthy "we/they" syndrome has developed in ATS. Individual controllers feel that "nobody is listening to them", and they perceive that management at the national level is being rewarded for inaction or inappropriate action.

Interpreting subjective feedback from individuals is virtually impossible. However, it is believed that there is sufficient evidence to indicate a potential for serious breakdowns in employee/management communications which could adversely affect safety.

11.5.2 Managerial Contact

One of the reasons for the apparent gap in employee confidence in management may be the lack of adequate contact between management and the employees. Every level of management interviewed commented on the totally unsatisfactory situation today whereby first-line supervisors are not being permitted to supervise, by virtue of the operational requirement to have them working the boards for an excessive amount of time. As discussed in Chapter 7, Supervision, Transport Canada has recognized the importance of restoring the supervisor to his former role in ensuring quality control in air traffic control and in representing employees' observations to more senior management. However, to take supervisors off the boards to maintain an operational overview requires additional staff - not just a PY allocation.

As discussed in Chapter 7, Supervision, management's real operational representative on the floor of a Centre today is the shift manager. However, as already discussed, the shift manager's position is not held in high esteem by controllers or supervisors. Hence, with supervisors not supervising and with current perceptions of the shift managers' competence and role, a significant breakdown in the contact between management and the employees occurs right on the floor of the operational centre.

An attitude has developed which is best represented by one controller's observation, "You do your job and I'll do mine". The desired sense of teamwork is missing. Yet, Transport Canada officials accept this phenomenon, pointing out that it is endemic in the ATC community in the U.S.A., U.K., France, Germany, and Australia.

The 1987 study on the quality of worklife in the Montreal ACC[7] found significant worker dissatisfaction with the management style. Respondents spoke of a dictatorial style, based on the excessive use of power with little attention to human resources, creating a prison-like environment. Significantly, 86.2 per cent believed that managers did not receive sufficient training to prepare them for their role in dealing with people. Approximately 60 per cent expressed dissatisfaction with the level of collaboration between superiors and subordinates, and with the level of esteem and confidence of superiors for their subordinates. Such lack of confidence in management would tend to exacerbate any other rifts between employees and management.

Notwithstanding the foregoing, significant improvements in morale were reported by the controllers at the Montreal Centre and at Gander Centre which also reportedly had a morale problem in recent years. In both Centres, new unit chiefs are being attributed with an improved understanding of the employees' concerns and with making genuine efforts to accomplish what they can within the constraints of the current system.

11.5.3 Competence of Controllers

Given the break in managerial contact with employees noted above, some controllers expressed concern over the competence of other controllers working beside them. Controllers' cynicism regarding the knowledge verification tests and refresher training is discussed in Chapter 7, Supervision. In addition, feedback was received that many controllers would have difficulty passing a no-notice written examination on required job knowledge. One manager stated that in his opinion, if controllers were to be given a test without the so-called open book, 80 per cent would not be able to make it.

As worrisome as any shortcomings in knowledge of the controllers is a reported "camouflage" on the boards with respect to occurrences of loss of separation. In part, non-reporting of ATS operating irregularities can be attributed to a lack of adequate supervisory presence. (During the midnight shifts, with the exception of Gander, there is no requirement to have a supervisor or shift manager on duty!) Several controllers, including one shift manager, expressed the view that many loss of separation occurrences are not officially reported.

An even darker side of this issue is its susceptibility to "blackmail." Indeed, given the absence of an effective managerial presence, some controllers may be taking the issue of controller competency into their own hands. Some have acknowledged that, if they are uncomfortable working beside a weak controller, they will ensure that any operating irregularities are reported. On the other hand, it would appear that, in other cases, controllers are protecting their peers and possibly even their supervisors - sometimes for several years - by not reporting operating irregularities. However, one controller stated "I do not expect to sit alongside a control position, watching a supervisor make errors and mistakes while controlling traffic and having the same supervisor on the following day telling me how I should control traffic." The potential for inappropriate pressure tactics within a team of controllers is not consistent with safety.

Yet, even when management is aware of a weak controller, they have sometimes been reluctant to take action. Dependent upon their occurrence record, these weaker controllers must be relieved of their duties, brought up to standard through training, or if necessary, even reassigned. Naturally, during the current period of staffing shortages, management is reluctant to lose even more controllers. As one unit chief said "Currently we are depending very much on the goodwill of controllers for their performance; it's no time for supervisors to begin using the hammer approach. First of all we have to get the staff numbers up, and then we can start working on the quality of performance." (Indeed, when there is an operating irregularity and a controller is required to be immediately removed from his/her duties pending further investigation, management may be unable to do so - given the difficulties in quickly finding a qualified replacement.)

While the investigating team certainly found nothing to indicate a general lack of competence by today's air traffic controllers, the feedback received concerning competence and the handling of weak controllers is cause for immediate concern. Again, urgent attention to redressing the current supervisory issue is required to redress all facets of this problem.

11.5.4 Operational Condition Report (OCR) Program

Since 1979, Transport Canada has operated an OCR program whereby all employees of the ATS branch are encouraged to comment on any item that they feel impedes the achievement of operational effectiveness. The number of OCRs submitted annually increased steadily until 1985, reaching 146. Since 1986 there has been a reversal of the trend with only 74 OCRs submitted in 1988.

During the field interview phase of this Special Investigation, several interviewees reported frustration with the OCR system. Some reported submitting OCRs on such items as their head-sets; they stated that they received neither acknowledgement nor action to their statements of concern. Another reported submitting an OCR five years ago when an emergency transceiver was splashing onto other frequencies; apparently he received no reply. Another stated an operational requirement for a hot-line with Sault Ste Marie Tower in an OCR, but reportedly received no answer.

While, individually, such complaints may appear rather mundane, collectively, they erode the employees' confidence in management and contribute to the sense of despair and resignation discussed above. Indeed, the recent drop-off in controller participation in the OCR program may well be attributable to controllers' perceptions on the futility of submitting an OCR.

On 23 June 1989, Transport Canada issued an ATC Information Bulletin on the OCR program. Clearly improved communications between employees and management within the ATS branch are being sought. The Information Bulletin prescribes procedures for processing OCRs which should ensure a higher level of managerial attention to OCRs than in the past. A revitalized OCR program could go a long ways toward improving current employee/ management relations.

11.6 SAFETY EDUCATION

One of the points remarked on by the pilots on the investigating team was the almost complete absence of an ATS safety education program. Pilots are accustomed to a continuous flow of safety related information. Transport Canada maintains a large organization devoted entirely to aviation safety promotion. Courses, seminars, films, posters, etc. are used in this process as well as meetings devoted to discussions of safety issues which serve also to enhance communications within the organization. This promotional material is aimed largely at pilots and aircraft maintainers. Although the ATS Branch does provide some educational/awareness material for controllers (e.g., Squawk 7700), the process in ATS does not seem to be as well developed - perhaps because it is a purely internal matter. Indeed, since its inception in 1988, only three topics have been addressed by Squawk 7700 to date. Given the safety issues confronting ATS today, a comprehensive, multi-media, safety-awareness program, targeted specifically within the ATS Branch, warrants consideration.

11.7 QUALITY CONTROL

On a national basis, there is evidence that quality control in the provision of ATS varies significantly. In Chapter 7, Supervision, several shortcomings in the provision of the various quality control programs at the ACC level were discussed. Ideally, operational proficiency is regularly evaluated by:

- Direct observations of controller's performance by supervisory over-the-shoulder observation;
- The Phraseology Improvement Program, whereby controllers' communication skills are evaluated through formal tape monitoring;
- Formal assessment of controllers' application of procedures in the event of radar failure; and,
- The annual knowledge verification test.

Staffing shortages have compromised supervisory availability to conduct these essential quality control programs. Furthermore, the staffing shortages have compromised the units' abilities to make personnel available for their required annual refresher training. Many controllers reported not receiving any refresher training; others reported receiving only two days training of the annual five-day requirement. This, in turn, compromises the consistent application of national standards.

Difficulties in attracting the most appropriate personnel to assume instructional duties and the inconsistent application of training standards for new instructors draws into question the quality of the instruction currently being provided at the unit level. The Special Investigators are not aware of any national program for the maintenance of standards in the training of new controllers at the unit level.

The ATS Branch does have an Evaluation Division which has a two-fold responsibility: conducting unit evaluations across the country and convening Fact Finding Boards for the investigation of ATC operating irregularities. At the time of the field survey of this Special Investigation, only Toronto Centre had received a comprehensive unit evaluation by the Evaluations Division in the preceding year. It is suspected that the Division's heavy involvement in the investigation of ATC operating irregularities is compromising their ability to systematically conduct unit evaluations. In other words, by focusing on individual occurrences, the Evaluation Division may be missing the opportunity to reduce the number of occurrences through comprehensive unit evaluations.

According to Transport Canada, in 1987 the Evaluations Division evaluated only one ACC, one TCU and 10 towers due mainly to a shortage of personnel within the division. However, in 1988 and 1989, a total of four ACCs, six TCUs and 51 towers have been evaluated. During the fall of 1989, unit evaluations were conducted at Gander and Montreal ACCs, and it is understood that a unit evaluation will be conducted at Vancouver early in 1990. Thus, all ATC units have been evaluated within the last three years which is in keeping with Transport Canada's ATS evaluation policy.

Nevertheless, given the current staffing crisis, the frequency of serious ATC operating irregularities, a major organizational change within the Department with respect to IFR operations, the forthcoming implementation of significant equipment enhancements, forecast traffic growth for the next decade, and anticipated high staff turnover, it is essential that the Department ensure the consistent application of the standards and procedures prescribed nationally. More frequent systematic, comprehensive monitoring of ATC operations may be required.

11.8 CANADIAN AIR TRAFFIC CONTROL ASSOCIATION

CATCA is responsible by law for bargaining, on behalf of its members, for wages, hours of work, and working conditions. As the professional association for the controllers, it also establishes the members' code of ethics and plays a key role in setting the tone regarding members' attitudes towards safety, the work environment, and professional conduct. The Association is well-organized and capable. It is one of the key players on the ATC scene and has a very important role to play in any attempt to resolve the problems which this Special Investigation has identified.

The CASB met with representatives of the CATCA in early 1989 to discuss safety issues in ATC. During the field survey phase, Investigators also interviewed CATCA representatives. Clearly, CATCA's principal concern is the shortage of controllers available today. CATCA membership is down significantly since 1983, the average age of Canadian controllers is "alarmingly high", and, consequently, the current retirement rate is exacerbating the shortage of controllers.

From a safety perspective, CATCA representatives expressed concern over a growing lack of backup or redundancy within the ATC system. One-man sectors are often opened when two or even three controllers might be required to provide the necessary backup; e.g., a data controller, a radar controller, and a terminal coordinator. Current staff shortages are contributing to further reductions in this backup, requiring more overtime by all employees and requiring supervisors to spend up to 90 per cent of their time controlling aircraft.

At the January 1989 meeting with the Board, the CATCA representatives commented on the power of the almighty dollar as a motivator for controllers to work up to 16 hours a day and even 21 to 23 days without a day off (in spite of the contractual agreement limiting work to nine consecutive days, at which time the employer is obliged to provide a paid day off). Indeed, CATCA suggested a need for a re-examination of maximum working hours per day, and maximum consecutive working hours on a radar position, etc. As discussed earlier in this report, the feedback from the controllers was virtually universal that the current reliance upon overtime is excessive and perhaps even abusive. Controllers spoke of the current situation as being "criminal" in terms of its potential impact on safety and spoke of using up two years of their life for each year worked under the current working conditions.

From its earliest contract negotiations with Treasury Board, CATCA fought for and convinced Treasury Board to accept the fact that fatigue is a vital consideration in scheduling of controllers. Given the widespread concern over the excessive reliance on overtime from both a safety and a human perspective, the Special Investigators were disappointed to see little evidence of any new initiatives by CATCA to intervene on behalf of their membership. Indeed, CATCA seems to be implicitly condoning the maximization of days off and overtime pay at the expense of widespread reported fatigue among its membership. One unit chief interviewed expressed surprise that he had not received any complaints from CATCA concerning the overtime issue.

Investigators were also dismayed by the CATCA's response to the need to help their membership cope with the current shortages in personnel. Since current staffing shortages result in safety as well as human concerns, the Investigators anticipated that CATCA would be defining the incentives necessary to attract qualified personnel to relocate. CATCA representatives in January 1989 deflected questions concerning the possible relocation of controllers to the busier Centres. It was CATCA's view that this is a labour-relations issue and should be resolved accordingly.

While relocation policy and relocation incentives are within the employer's discretion, having the Association's blessing on whatever outcome would do much to promote its acceptance.

11.9 INVESTIGATION OF ATS OCCURRENCES

When the CASB is apprised of an occurrence involving a loss of separation between two aircraft, a decision is made as to whether the CASB will investigate that occurrence. This decision is based upon an assessment as to whether a risk of collision existed. Consideration is given to such factors as the degree to which normal separation criteria have been compromised without being monitored; whether evasive action to avoid a collision was required; whether an aircraft was cleared or attempted to land or take-off when another aircraft or vehicle was on the runway, etc. Typically, the CASB investigates two or three dozen occurrences involving ATC operating irregularities or losses of separation each year. These occurrences have been judged to have had the highest accident potential.

When the CASB decides not to investigate a particular ATC occurrence, Transport Canada may initiate an investigation of its own and/or take enforcement action in the case of regulatory infractions. Historically, Transport Canada conducts 140 investigations of ATS operating irregularities or losses of separation each year. If these occurrences involve ATC, the investigations are conducted by Fact Finding Boards comprised of experienced air traffic controllers. As noted in Chapter 3, 362 Fact Finding Board reports are included in the database of this Special Investigation; many of these were reviewed during the file review phase of the investigation. Many of the occurrences which the CASB initially judged as not warranting a CASB investigation did in fact involve aircraft that met the established criteria for a CASB investigation. In other words, the process for deciding which occurrences the CASB will investigate is not working properly. In some cases, the details are not being accurately reported to CASB; in other cases, even though the CASB's criteria were met, a decision was made not to investigate for other reasons.

In Chapter 3 of this Special Investigation, it was pointed out that only 513 of the 710 occurrences in the database created for this Special Investigation are included in the Canadian Accident/Incident Data System (CAIDS). Annex A to Chapter 3 pointed out the disposition of the 197 incidents not recorded in the CAIDS database; as explained in that annex, the disparity is decreasing each year. However, even in 1988 there were still 21 occurrences which were not adequately reported so as to be recorded in the CAIDS. Furthermore, the data collected differs depending on whether a Fact Finding Board report or a CASB investigation report is the source; Fact Finding Boards have a more systematic approach to basic data capture. In other words, the current method used for identifying, reporting, and recording ATS loss of separation occurrences results in serious inconsistencies and shortcomings in the principal database used by the CASB for the macro analysis of such occurrences - particularly with respect to the collection of pertinent human performance data.

Recently a new type of investigation by Transport Canada has been implemented to investigate occurrences involving flight service station personnel; these investigations are known as Operating Irregularity Investigation Reports. It is too early to assess the safety value of this investigative process.

As stated in Chapter 1, in 1987 a consultant for the CASB reviewed 294 Fact Finding Board Reports prepared by Transport Canada. The consultant found that "Fact Finding Boards were generally of excellent quality and appeared to be both objective and thorough." At that time, the CASB staff were also satisfied that the Fact Finding Board process was identifying safety deficiencies in the ATS system and Transport Canada was initiating appropriate remedial action thereto. For example, new frequencies were added from time to time, letters of agreement were amended, controller refresher training was provided, etc.

While the CASB staff continue to believe that the Fact Finding Board process is generally effective in identifying contributing factors to specific occurrences, the file review phase of this Special Investigation showed that the Fact Finding Board process has tended to overlook deficiencies in supervision, the quality control programs, and staffing and workload issues. In other words, managerial considerations do not appear to have come under the same critical scrutiny through the Fact Finding Board process as individual controllers' work habits and procedures. Furthermore, Fact Finding Board reports have not reflected an in-depth investigation and understanding of the contributing human performance factors - such as those discussed in Chapter 9. Feedback received during the field survey phase of this Special Investigation underlines this concern.

There is a perception among some controllers that too many straightforward occurrences are investigated by Fact Finding Boards, even after a local unit investigation has been completed. This results in an apparent waste of controller time, when there is already a shortage of qualified controllers. Further, there is a perception among some controllers that, following a Fact Finding Board, management believes that something must be done to preclude recurrence; therefore yet another procedural change is introduced. Frequent changes to procedures have already been noted as a cause for concern among controllers. As one controller stated, "many procedural changes are made as a result of a Fact Finding Board where there was nothing wrong with the procedure and the incident was directly attributable to a human error." A suspicion was also reported that Fact Finding Boards tend to represent the managerial perspective and therefore lack objectivity.

The need for independence and objectivity in the investigation of aviation occurrences is the foundation of both the CASB Act and the new CTAISB Act. While the preponderance of argument by Mr. Justice Charles L. Dubin[8] focused on the elimination of the appearance of conflict of interest with respect to accident investigation, his final report does state:

> "Virtually all the same arguments in favour of an independent tribunal for accident investigation apply with equal force to incident investigation. For these reasons, I am of the opinion that the jurisdiction to investigate all incidents relating to civil aircraft should be assigned to an independent tribunal. ... That would include incidents which may be related to air traffic controllers .... "

As pointed out by Mr. Justice Dubin, in addition to real independence and objectivity for such investigations, there must be a perception throughout the aviation community that such independence and objectivity in fact exists. Notwithstanding the quality of the Fact Finding Boards into ATS operating irregularities reviewed by the CASB, the perception that independence and objectivity are lacking warrants further examination of the investigation process. Several controllers and CATCA representatives spoke of the need for an independent investigation of all loss of separation occurrences; i.e., by the CASB.

Fortunately, most loss of separation occurrences only result in incidents with a relatively low risk of mid-air collision. Nevertheless, the factors contributing to such losses of separation frequently can have equal potential for creating an actual mid-air collision situation; therefore, there are important lessons to be learned about prevention. Indeed, the probability of fully understanding these contributory factors is more likely following a thorough investigation of an incident than after a mid-air collision where much of the evidence would be destroyed and where extreme emotion and self-interest can colour the testimony of the various parties of direct interest. In other words, there is at least as great potential (if not greater) for preventing accidents through the investigation of loss of separation incidents than through the investigation of mid-air collisions.

While the CASB has investigated 75 of the 710 loss of separation occurrences which fell within the scope of this Special Investigation, its focus has been on those occurrences where the circumstances brought the aircraft closest to an accident. The CASB has not been able to dedicate resources to the investigation of all those incidents (which may be more instructive with respect to accident prevention) where the risk of collision was less severe.

To understand the contributory situations and conditions which led to these less critical incidents, the CASB has had to rely upon the investigations conducted through Fact Finding Boards. The reports are designed to meet Transport Canada's requirements, but are not always suitable to fully meet the CASB's objectives. For instance, they do not include evidence from personnel other than air traffic controllers; e.g., the pilots involved in the occurrence are not interviewed for their perspective, nor does a pilot regularly participate as a member of a Fact Finding Board.

Conversely, investigations of ATS operating irregularities by the CASB have been limited by the absence of in-house ATC expertise. The CASB has not continuously had a controller on staff, and, when there has been an ATS specialist in the employ of the CASB, his availability for investigation in all the regions has been stretched to the extreme. Consequently, many of the CASB's conclusions regarding investigations into ATS operating irregularities are coloured by a Civil Aviation Inspector's (or pilot's) perspective, without a deep professional understanding of the ATC perspective. Hence, there is concern that critical issues may be overlooked, and valuable information may not be provided by the ATS personnel during interviews because the line of questioning pursued by the investigator may overlook the fundamental problems contributing to the occurrence. The lack of ATS competence among the CASB staff pertains equally to the analysis of safety deficiencies; most CASB safety deficiency analysts have little or no experience in investigating and analyzing the causes and contributing factors to controller-induced losses of separation.

A more balanced approach to the investigation of individual ATS operating irregularities is required. The perspectives of both ATS specialists and pilots are required in the investigation of ATS operating irregularities. Furthermore, given the importance of incident investigation to the development of understanding essential to accident prevention, and the need for independence and objectivity in occurrence investigation, the CASB or its successor should play a greater role in the investigation of risk of collision occurrences. To this end, the CASB or its successor will require increased resources and ATS expertise, and the decision-making process for selecting risk of collision occurrences to be investigated by the CASB or its successor must be refined.

In a similar context, in Volume 1 of the First Report on Air Traffic Control Safety submitted to the Transport Committee of the British House of Commons (printed 08 February 1989) one of the 47 recommendations therein pertained to this issue. Specifically the report stated:

> "Whether justified or not, it is all too easy to accuse the CAA of being judge and jury in its own court. We recommend that free-standing (air miss) investigative machinery be set up; given the use of staff secondments, the extent to which expertise will need to be duplicated should be minimal. But if duplication is required we consider it to be a price worth paying."

For the most routine investigations, the CASB or its successor may have to delegate the investigation to Transport Canada; however, any Fact Finding Board Reports or Operating Irregularity Investigation Reports made by Transport Canada should be made available to the CASB or its successor for formal monitoring. Such change to current operating practices is required to restore confidence that independent, objective, and balanced investigations of ATS operating irregularities involving risk of collision occur.

11.10 OBSERVATIONS

1. Transport Canada has a coherent system for planning the continued effectiveness of the Air Navigation System beyond the year 2000.

2. The Canadian Air Space Systems Plan is ambitious and expensive; if implemented as planned, it should provide an adequate equipment base for the safe and effective control of air traffic into the next century.

3. The Canadian Airspace Review is an exemplary model of what can be achieved through the consultative process with industry; the CAR's Recommendations, when implemented, will go far toward redressing many of the deficiencies confirmed through this Special Investigation.

4. Current staffing shortages are in large part attributable to shortcomings in national staff planning for the long term for ATC. The conflicting objectives of downsizing in government and accommodating growing traffic levels have not been satisfactorily reconciled. Clearly, the Department does not have an adequate process for bringing together at the national level all of its operational and staff planning in an effective manner for ensuring the availability of necessary human resources to meet operational ATC requirements.

5. The staffing get-well date of 1994 in Transport Canada's current National Staffing Plan should be cause for considerable concern, given anticipated increases in traffic levels and growing disenchantment among the controllers keeping the system operating through overtime.

6. The employer does not appear to be considering the types of incentives that would be necessary to entice controllers to relocate and thereby achieve a more optimal distribution of the current qualified staff available vis-à-vis the workload demands.

7. Meeting future demands in air traffic control will not likely be met through further refinement of the controllers' tactical workload; rather, a fundamental, philosophic change in ATC operations is required to achieve more strategic control of air traffic by altering the controllers' work such that they become ATC systems managers.

8. A "we/they" syndrome exists between controllers and managers throughout the system. This perception derives from the breakdown in managerial contact at the supervisory level. Fundamental change will be required to develop a more collegial/team approach to daily operations.

9. While the investigating team found nothing to indicate a general lack of competence by today's air traffic controllers, the evidence suggests that the identification and handling of weak controllers in the system may not be consistent with safety.

10. Current efforts by Transport Canada to reinvigorate the Operational Condition Report program have the potential to improve employee/management relations.

11. Transport Canada's safety promotion and awareness material aimed specifically at ATS personnel is quite limited compared to that available for pilots and mechanics.

12. Given the currently dynamic and potentially volatile circumstances in ATC operations in Canada, an increased level of monitoring is warranted - particularly at the busiest Centres - to ensure the consistent application of national operating standards.

13. CATCA could play an influential role in offering acceptable ways of alleviating the current problems of staffing shortages, training, attrition, workload, overtime, controller disenchantment, early retirements, etc.

14. Risk-of-collision occurrences are currently being investigated either by CASB or Transport Canada, neither agency having the resources or processes to consistently investigate all such occurrences and to capture all the data relevant to accident prevention. For more meaningful analysis of investigations of these occurrences, greater consistency in the collection of data will be required - regardless of the investigating agency.

LIST OF REFERENCES

1. TP4334E Canadian Airspace Systems Plan, September, 1988.

2. TP8383E Canadian Airspace Review, 14 February 1989.

3. TP5390E "Economic Evaluation Criteria for Establishment and Discontinuance of Airport Control Service", Volume 1, Second Edition, October 1986.

4. Levesque, J., Director General of Euro Control " Future Concepts - Air Traffic Management in Europe Up to the Turn of the Century".

5. Viewpoint "Controllers Decide, not Computers", Jane's Airport Review August/September 1989.

6. GAO/RCED89-112 United States General Accounting Office Report to Congressional Requesters, "Aviation Safety: Serious Problems Continue to Trouble the Air Traffic Control Workforce", April 1989.

7. Bernier, Diane, et Luc, Edith "La qualité de la vie au travail au centre régional de contrôle aérien de Montréal Ministère de Transport", juin 1987.

8. Dubin, The Honourable Mr. Justice Charles L., "Report of the Commission of Inquiry on Aviation Safety", May 1981, Volume 1.

CHAPTER 12

CONCLUSIONS

12.1 GENERAL

Meeting today's operational demands for air traffic services is a large, costly, and complex task. Transport Canada is coping remarkably well in providing the levels of service required. The ATS system handles thousands of flights daily, and losses of separation are relatively infrequent. By almost any standard but that required for aviation safety, the error rate in the ATS system would be considered to be unbelievably low. However, in contemplating the possibility of collision between large passenger-carrying aircraft only a zero rate is acceptable.

Throughout this Special Investigation, the CASB has been impressed by the dedication and willingness of all the controllers and managers who participated to meet the operational demands SAFELY - regardless of how difficult. Indeed, even when the criteria for the separation of aircraft were violated, more often than not there was little or no real risk of collision. Nevertheless, the frequency and gravity of occurrences where there was a real risk of collision are cause for concern.

This Special Investigation Report is the culmination of more than a year's concentrated efforts. It has examined in considerable detail, as well as from the broadest perspectives, the contributing factors to potentially dangerous loss-of-separation occurrences. As can be seen in the foregoing chapters, there are few quick fixes. The pursuit and maintenance of safety in the provision of ATC services will be a never-ending quest.

While there have been no midair collisions involving aircraft over 12,500 pounds maximum take-off weight in Canada since 1970, the vast majority of the 710 reported incidents in the 1985 to 1988 period involved at least one large aircraft (maximum take-off weight of more than 50,000 pounds), operated by a scheduled operator, flying under IFR. The majority of the reported incidents were technical losses of separation rather than serious risks of collision. Evasive action by one or both aircraft was reported in 19 per cent of the incidents. The frequency of occurrences appears to be disproportionately high at the busiest airports; Toronto and Vancouver are at the upper end of the data in both movements and incidents.

Human performance factors were assigned by the CASB's safety analysts in 88 per cent of the 217 files selected for more detailed review; planning errors, judgement errors, and lapses in attention accounted for almost 60 per cent of these.

In 44 per cent of the files reviewed, operations factors were found to be contributory, usually involving procedural, coordination, or supervisory considerations.

In 43 per cent of the occurrences, staffing considerations were noted; there was either a working supervisor or an inadequate number of staff on duty at the time of the majority of these occurrences.

The CASB believes that this Special Investigation has produced an accurate and balanced assessment of the safety considerations related to the provision of ATC services in Canada today. While the examination has not been exhaustive, it is believed that the occurrences examined and the statements provided to the investigators are adequate evidence of endemic problems across the country. Although the ATC system is operating remarkably well in most respects, urgent attention to the major issues addressed in this report is required to ensure the continued safe separation of large carrier aircraft on IFR flight plans from known traffic in Canada.

The following paragraphs summarize several of the more critical safety deficiencies and offer suggestions to improve the level of safety in the provision of ATC services in Canada. These are organized to follow the principal themes of this report; i.e., equipment, staffing and workload, training, supervision, procedures, human performance factors, information transfer, and management issues.

12.2 SAFETY ACTION REQUIRED

12.2.1 Equipment

Although equipment-related problems were found to be contributory in less than 10 per cent of the occurrences, there is evidence that many occurrences involving human performance factors may have been precipitated by equipment shortcomings; e.g., missed readback error due to improperly fitting head-sets, misunderstood clearance due to frequency congestion, etc.

12.2.1.1 Modernization

Current plans within Transport Canada to upgrade ATC equipment reflect a coherent and balanced appreciation of technological capabilities vis-à-vis projected operational demands. However, the implementation time frames leave the ATC system vulnerable to overload in the short-term. In particular, any further slippage in implementing the Radar Modernization Project or the Canadian Automated Air Traffic System will create serious problems in terms of the system's ability to safely handle continued traffic growth. Recognizing the bounds of technological feasibility, extra resources may have to be applied to ensure the implementation of RAMP and CAATS without delay. Indeed, incentives may be warranted for the CAATS contractor to bring the system forward early.

Even with the timely implementation of RAMP and CAATS, currently deployed systems will require continuing attention to bridge the intervening period. The current backlog of unsatisfactory condition reports and equipment change proposals reflect the need for incremental improvement in the effectiveness and safety of these systems. The potential for attaining these enhancements at marginal costs should not be overlooked as the major Crown projects are implemented.

12.2.1.2 Real-Time Surveillance on the North Atlantic

In view of the continuing frequency and magnitude of gross navigation errors involving large passenger-carrying aircraft over the North Atlantic Ocean, the "safety net" needs to be strengthened. Since gross navigation errors can be expected to occur due to human errors, some form of real-time monitoring of the aircraft's position by controllers is required to detect such errors and to initiate conflict avoiding action. International cooperation through ICAO will be required to implement such a real-time surveillance capability on the Organized Track Structure over the North Atlantic. Canada, as a provider nation for air traffic service over the North Atlantic should play a critical leadership role in seeking real-time surveillance.

12.2.1.3 DCPC over the North Atlantic

Today's transoceanic communications problems are related to exclusive reliance upon an outmoded technology. In view of the continuing increases in transoceanic travel, the unacceptability of HF communications for the timely control of air traffic, the absence of a real-time surveillance capability over the North

Atlantic, and the quality of communications now technologically feasible through satellite-based systems, international cooperation is required through ICAO for the early implementation of a satellite-based direct controller/pilot communications in the Organized Track Structure over the North Atlantic. Such DCPC could be by voice communications or by data link.

With respect to satellite-based improvements in communications, navigation, and surveillance systems over the North Atlantic, it is the view of the CASB that the need is greatest for improvements in the communications and surveillance systems. Aircraft meeting today's Minimum Navigation Performance Specifications are already technically capable of accurate transoceanic navigation.

12.2.1.4 Technology Enhancements

There is some evidence that Transport Canada is not taking full advantage of the technological capabilities available today through relatively low-cost computerized equipment. For example, GAATS, NACS, and GAMP are small computer applications that significantly enhance the control process - each with its own virtues. However, there does not appear to be any process for integrating the best features of each; e.g., NACS has a good visual display system, GAATS does not. To improve the effectiveness of information transfer between individuals, an integrated plan for the implementation of small computer-based systems will be required.

12.2.1.5 Airborne Collision Avoidance Systems

Given the frequency and severity of loss of separation occurrences involving transport-category aircraft on IFR operations in Canada, some form of airborne collision avoidance system is required for Canadian flight operations in order to provide flight crews of these aircraft with the necessary information to avoid collisions when all other forms of separation fail.

12.2.1.6 Control Tower Layout

In busy towers, the airport controllers' work often requires almost instantaneous decision-making. The ready availability of all relevant information is essential to this process. In view of the reported problems with the layout of airport controllers' information displays and work stations, an evaluation of control tower layouts is required with a view to implementing an ergonomically efficient configuration suitable for high workload conditions.

12.2.1.7 Indicator Modules

There is limited system expansion capability for the provision of IFR services in the short-term, and few if any maintenance spares, due to the non-availability of extra indicator modules in the Centres. Contingency plans are required, pending the implementation of RAMP, to ensure the continued availability of high quality radar presentations for each sector in the busiest specialties employing radar separation criteria.

12.2.1.8 Frequency and Telephone Availability

Lack of assigned frequencies is leading to frequency congestion, which in turn contributes to the many forms of human error related to information transfer problems. Safe air traffic separation depends upon timely communications and coordination. High utilization rates on some frequencies and dedicated telephones can compromise the timeliness of this process. Controller workload and anxiety could be decrease by reducing the saturation of today's communication systems. Additional radio frequencies and dedicated telephone lines are required where the level of current voice communications is compromising the timely transfer of information essential to safe flight.

12.2.1.9 Head-sets

During the field survey many controllers expressed dissatisfaction with their head-sets. Controllers are reportedly missing readbacks of clearances due to poor fitting head-sets. Given the susceptibility of oral communications to human error, and given the frequency with which communications-related factors are contributory to ATC occurrences, each controller should be provided with a reliable head-set which is suitable to the individual. Furthermore, each controller should make appropriate use of this head-set at all times when occupying a control position.

12.2.2 Staffing and Workload

12.2.2.1 Staffing

The most serious operational problem facing the ATC community today is the shortage of qualified controllers in most of the ACCs and in the Toronto Control Tower. From a safety point of view, staffing shortages frequently result in single-controller sectors, sector consolidation, increased controller workload, fewer relief breaks and days-off, etc. - all of which may have a detrimental impact on the safety margins of human performance. Given the current staffing problem, a new managerial approach is needed for forecasting, recruiting, and training sufficient air traffic controllers to meet current and anticipated operational demands. For example, a program of financial incentives is required to attract qualified air traffic controllers to relocate to busier ATC units. Furthermore, airport control service at selected low traffic airports may have to be curtailed, thereby releasing qualified controllers for relocation to under-staffed units where the risk of collision is higher.

12.2.2.2 Overtime

The general view is that workload within the ATC system has risen dramatically in the past five years. Compensating for the increased workload deriving from staff shortages and increases in traffic through increasing reliance on voluntary overtime has lead to a significant increase in the number of hours worked by individual controllers and a corresponding decrease in their number of days off. In the eyes of many, overtime has become "the glue that holds the ATC system together today." There is strong consensus among controllers, supervisors and some managers that the situation is rapidly nearing safe limits. Some individuals are influenced by the financial benefits of overtime and work excessive numbers of extra shifts. Indeed, the collective agreement with the controllers provides considerable financial incentive to work excessive overtime. In some cases, the provisions of the collective agreement regarding maximum consecutive days of work for air traffic controllers are not being followed.

Since excessive reliance on overtime presents serious potential for controller fatigue and may exacerbate the current staffing shortage through increased sick leave and ultimately increased controller attrition, several measures are required. For example, limitations on the number of overtime shifts permissible in any nine-day cycle and in any month may be necessary, possibly through mandatory overtime for controllers not now working extra shifts. Enforcement of the provisions of the collective agreement regarding maximum consecutive days of work for air traffic controllers is also required, and immediate steps should be taken to renegotiate the contract with the air traffic controllers to remove the financial incentive to work excessive amounts of overtime.

12.2.3 Training

12.2.3.1 Production

In view of the growing gap between operational demands and the availability of qualified air traffic controllers, training production must urgently be increased to ensure a continued satisfactory margin of safety in the provision of ATC services. The alternative is further reductions to the levels of service at busy centres. Procedures are required for fast-tracking the best controller candidates recruited directly into the ATC training system. The concept of specialization during basic training for the VFR and IFR concentrations should be vigourously pursued. Also, further specialization in qualification training at the unit level, for selected sectors of a specialty if necessary, should be considered to prepare trainees for operational duties as quickly as possible, upon assignment to an operational unit. For the longer term, consideration should again be given to providing the necessary educational basis for a full career in ATC through community college programs.

12.2.3.2 Attrition

Production of a sufficient number of qualified controllers has been compromised by continuing high attrition during training. Much of this attrition occurs late in the training process and appears to be related to the current training philosophy and methods used in selection, training, and job assignment. Since continuing high attrition in training is delaying recovery from the current staffing shortages, the selection criteria and screening processes may have to be modified to absorb most training attrition within the first few weeks of basic training. Furthermore, initial assignments of controller candidates to operational units should be based upon the strengths and weaknesses of the individual as demonstrated during basic training. Indeed, an apprenticeship training program to develop air traffic controllers to fulfil progressively more responsible operational duties should be considered, and unsuccessful candidates from qualification training in the most demanding units should be assessed for reassignment to requalification training at less demanding units.

12.2.3.3 Instructor Availability

Transport Canada is experiencing difficulties in attracting a sufficient number of qualified candidates for instructional positions throughout the ATC training system. Since success rates in training and the overall quality of ATC services provided is critically dependent upon the quality of instruction received during training, incentives are required to attract appropriate controllers to periodically assume instructional duties at the ATS Training Centre, in the Regional schools, and as on-the-job instructors. Consideration should also be given to the training benefits to be accrued by making the Chief of the ATS Training Centre at TCTI directly responsible to the Director of Air Traffic Services.

12.2.3.4 Instructor Training

Current staff shortages are precluding on-the-job instructors at the operational units from receiving appropriate instruction to develop the pedagogical skills necessary to help the trainees attain their maximum potential. In view of the extremely high attrition rate sometimes being experienced at the ACCs, a formal program for the qualification of on-the-job instructors is required.

12.2.3.5 Simulation

The use of simulation in ATC training is lagging significantly behind current technology and contrasts unfavourably with the increased use of simulation as an effective training tool found in other segments of the aviation industry. Given current staff shortages and the very high wastage rates during training, simulation offers considerable potential for improving training effectiveness. Accelerated development and implementation of full-mission or part-task simulators for use in basic, qualification, and recurrency training is required.

12.2.3.6 Refresher Training

Over the last several years, staff shortages have resulted in many controllers not receiving their required refresher training. In view of the criticality of maintaining currency on all required control techniques applicable to the specialty or subunit, a revitalization of the refresher training program is required on a national basis to ensure the continuing capability of operational controllers to cope with all eventualities to the standards prescribed in MANOPS.

12.2.4 Supervision

12.2.4.1 Role

The first-line supervisors are principally responsible for assuring the day-to-day quality which enhances safety in the ATC services provided by their subunits. However, since many supervisors are required to spend up to 90 per cent of their work time at a control position within their subunit, they are unable to perform the traffic management, workload balancing, and overseeing functions required of a first-line supervisor. In view of the importance of sound supervision to the safe functioning of the team, a fundamental change in philosophy in the role of the supervisor is required. Operational restrictions are required for supervisors performing in a direct control position; e.g., not more than 50 per cent of the time during any one shift, never above Pace Level Four, etc.

12.2.4.2 Incentives to Supervise

Among controllers, there has been a perceived degradation in the role of the first-line supervisor, which has resulted in many controllers not aspiring to become supervisors. In one centre, six supervisors have recently chosen to leave the supervisory ranks. In order to attract the most suitable controllers to the supervisory ranks, a new program of incentives for operational supervisory personnel is required.

12.2.4.3 Training for Supervisors

More often than not, operational controllers advance to supervisory positions without any specific training on how to be an effective supervisor. Since the effectiveness of an ATC team is directly related to the quality of supervision, an instructional program on the principles of supervision is required for all controllers being prepared for operational supervisory responsibilities.

12.2.5 Operating procedures

12.2.5.1 Introducing Change

There are significant shortcomings in the current methods used to introduce procedural changes among controllers. In view of the importance of the consistent implementation of standardized operating procedures to the safe operation of flight, the current processes for the implementation of new procedures should be re-evaluated, including consideration of the use of computer-assisted learning and/or video packages - particularly for "mandatory briefing" items.

12.2.5.2 Transfer of Control

One area of concern that frequently arose during the field survey phase of this Special Investigation concerned the transfer of control from the arrival controller to the tower controller under IMC. In view of the different interpretations by controllers as to the correct procedures to be followed for the transfer of control from terminal to tower controllers, clarification is required for controllers regarding the criteria, procedures, and consequences for the transfer of comtrol of IFR arrivals from a terminal controller to a tower controller under IMC.

12.2.5.3 VFR/IFR Mix

With increasing air traffic volumes, mixing VFR and IFR traffic in high density areas is becoming increasingly difficult. Human performance limitations in such situations are undermining the traditional precept of "see and be seen." In view of the continuing hazard to flight created by the mix of VFR and IFR traffic in and around major Canadian airports, particularly at Vancouver, extension of Mode C altitude reporting requirements at Canada's major airports is urgently required. In addition, the adequacy of the current Class C airspace dimensions and designated entry points for the Vancouver Terminal Control Area should be reassessed.

12.2.5.4 Opening and Closing Sectors

During the field survey, considerable feedback was received with respect to perceived inadequacies in existing procedures for the opening and closing of sectors. In view of the vulnerability of the air traffic system to human errors during opening, combining or closing sectors, and given current and expected staff shortages, operating guidelines for the timing, staffing, and transfer of responsibilities for opening and closing sectors are required.

12.2.6 Human Performance Factors

12.2.6.1 Vigilance

By far the most common contributory factors in ATS incidents were those that involved the human part of the system. Of the 217 incidents studied in the file review, contributory factors were identified in 182 or 88 per cent of the occurrences. Inattention, forgetfulness, lack of vigilance or whatever name one chooses to call it, appears to be contributory in approximately 50 per cent of all ATS occurrences. In view of the frequency and potential consequences of controller inattention, and in view of the general lack of understanding as to how to sustain vigilance in high performance tasks, research is required to find more effective means for sustaining controller vigilance. In addition, all technical initiatives with a potential for providing controllers with automated conflict prediction and alerting should be accelerated.

12.2.6.2 Fatigue

Typically, a controller's shiftwork cycle is disruptive to natural body rhythms. Working further shifts during the normal days of rest exacerbates the naturally fatiguing effects of shiftwork. Given the frequency of inattention errors, decision-making errors, information transfer and coordination problems, etc.; given the naturally fatiguing effects of a rotating shift cycle; and given the exacerbating effects of the current workload and overtime situation, further restrictions on the maximum duty times of air traffic controllers are required. These should include further restrictions on the maximum consecutive number of days worked, the maximum number of hours to be worked in any 24-hour period, and the maximum number of hours at a particular control position without a relief break. A program of basic research into the adverse effects of circadian disrhythmia and sleep deficits on air traffic controllers' job performance is also required. As well, research into the effects of regularly working overtime shifts during normal days of rest, on individual controllers' job performance should be conducted in Canada.

12.2.6.3 Aeromedical Consideration

American research has demonstrated the susceptibility of air traffic controllers to particular health problems. Counsellors in Transport Canada's Air Traffic Control Occupational Health Program have indicated that there has been a steady increase in stress-related complaints, usually associated with excessive overtime. In view of the importance of individual health and well-being to the long-term effectiveness of the controller workforce, a major lifestyle modification program for air traffic controllers through the Air Traffic Control Occupational Health Program is required.

12.2.6.4 Visual Perception

In approximately 9 per cent of the reported occurrences involving IFR aircraft in the database of this Special Investigation, one of the aircraft was operating under VFR. The "see and be seen" principle is not working well around major airports today. Given all the natural limitations of the human eye and mind, and given the technology available today, measures are required to reduce the reliance upon the visual acquisition by pilots of conflicting traffic for the maintenance of safe separation around Canada's major airports.

12.2.7 Information Transfer

12.2.7.1 Awareness of Problems

In more than one half of Fact Finding Board reports, communications or information transfer related problems are found to be contributory. In view of the frequency of ATC operating irregularities and the contributing failures in the oral information transfer process, and given the importance of effective inter-controller and controller/pilot communications to the safe separation of aircraft, an industry-wide initiative to enhance the understanding of all those involved in information transfer by radio telephony is required to underline the vulnerability of the communication process to human error. A program of pilot/controller familiarization visits, whereby pilots and controllers are given the opportunity to observe the performance of the other in their workplace under high workload situations, would also improve awareness in this regard.

12.2.7.2 Callsigns

While the Special Investigators found little evidence that callsign confusion had actually caused any recent ATC occurrences, feedback from pilots indicates that the problem is growing. The proliferation of similar-sounding company identifiers and/or flight numbers is conducive to misinterpretation. In view of the potential consequences of a flight crew inappropriately responding to a clearance or instructions intended for another aircraft due to callsign confusion, regulatory measures are necessary for the assignment of callsigns to be used during radio telephony.

12.2.7.3 Phraseology

Transport Canada's Fact Finding Board reports also frequently reveal a large number of deviations from standard phraseology during the preceding minutes leading up to an occurrence - even though they may not have been directly contributory. Since the effectiveness of information transfer in aviation is highly dependent upon the use of standard phraseology, and given the widespread deviations from prescribed phraseology identified by Fact Finding Boards, Transport Canada's Phraseology Improvement Program for air traffic controllers and flight service specialists requires rejuvenation.

12.2.7.4 Coordination

Inadequate coordination is a significant contributing factor to loss of separation occurrences. Growing workload, single-controller sectors, inattention and distraction, equipment limitations, procedural problems and airspace configuration are among the factors contributing to breakdowns in inter-controller coordination. Given the volume of oral information transfer required today, increasingly, efforts must be made to reduce coordination requirements between controllers and between controllers and pilots. In the longer term, increased use of data link should reduce pilot/controller coordination requirements. However, in the meantime, the requirements for aircraft operating in busy terminal airspace to be equipped with automatic pressure altitude reporting equipment responding to Mode C interrogations should be extended. Also, a feasibility study into the possibility of effecting automatic hand-offs from one ACC to another Centre using the Joint Enroute Terminal System (JETS) is warranted.

12.2.7.5 Gander Paper Handling

The International Flight Service Station at Gander processes between 2,000 and 3,000 HF messages per day in the relaying of requisite information between pilots and controllers. Given the inherent vulnerabilities of the antiquated system of flight following using paper strips and the inherent vulnerabilities of communications through a third party in the Gander Oceanic Control Area, immediate steps are required to streamline the message handling process created by today's absence of direct controller/pilot communications in the Gander Oceanic Control Area.

12.2.8 Management

12.2.8.1 Staff Planning

The most significant shortcoming in Canada's national planning for the provision of ATC services is in the area of staffing. The conflicting objectives of "downsizing" in government and accommodating growing air traffic levels have not been satisfactorily reconciled. A coherent, system-wide approach to staffing requirements within the ATS Branch, with new and innovative thinking, will be required to bridge the gap to the forecast the "get-well" date. In view of the diverse ways by which current and expected staffing shortages can undermine safety, a system-wide plan, making whatever accommodation is required (such as multi-year resourcing assurances) should be pursued as a matter of urgency to resolve the current staffing crisis in air traffic controllers and to ensure that controller availability over the longer term is sufficient to meet forecast operational demands.

12.2.8.2 Operational Decision-Making

The frequency of planning and judgement errors in the loss of separation occurrences reviewed, suggests a fundamental need for change in the ATS system. Today's ATC philosophy places almost exclusive reliance on tactical air traffic methods. Given today's technological capabilities, ways must be found to predict and resolve potential traffic conflicts as early as the flight planning phase. A plan for the evolution of the air traffic controllers' role is also required, so as to achieve increased strategic decision-making and decreased tactical decision-making for the safe separation of aircraft.

12.2.8.3 Employee/Management Relations

While differences in perspective between management and employees are normal, there is evidence to indicate a growing potential for serious breakdowns in employee/management communications which could adversely affect safety. Since safe separation of air traffic is dependent upon the maintenance of the highest standards of discipline and performance, a more effective managerial presence is required for the maintenance of effective employee/management relations in operations. Furthermore, an immediate investigation into the effectiveness of current methods used at operational units for the identification and handling of weak air traffic controllers is warranted.

12.2.8.4 Safety Promotion

Transport Canada has very effective safety promotion programs in place throughout the aviation community for pilots, owners and operators, servicing and maintenance personnel. However, there is little evidence of an equivalent safety promotional effort within the ATC community. Since organizations with good safety records almost invariably foster safety awareness among their employees through effective safety promotion, a comprehensive program for the promotion of safety awareness throughout ATS operations is warranted.

12.2.8.5 Quality Control

On a national basis, the lack of effective supervisory presence, difficulties in attracting personnel to become instructors, the large number of Fact Finding Boards being conducted, and abbreviated refresher training programs for controllers are all compromising the overall quality control in the provision of ATC services. Given the current staffing crisis, the frequency of serious ATC operating irregularities, the forthcoming implementation of significant equipment enhancements, forecast traffic growth for the next decade, and anticipated high staff turnover, it is essential that Transport Canada increase its efforts for monitoring ATC operations to ensure the consistent application of the standards and procedures prescribed nationally.

12.2.8.6 Investigation of ATS Occurrences

While the reports prepared by the CASB and Transport Canada in investigating hundreds of ATS occurrences were the foundation for this Special Investigation, several anomalies in the current system of split responsibilities between the CASB and Transport Canada for the investigation of risk-of-collision occurrences were revealed. Today's split investigative processes had not highlighted the many diverse and pervasive safety deficiencies identified through this Special Investigation. Since such safety deficiencies are compromising the effectiveness of Transport Canada's ability to deliver ATC services safely, the CASB should consider strengthening the investigation of ATS occurrences by:

- Refining the decision-making process by which the CASB decides to investigate risk-of-collision occurrences.
- Increasing the in-house capability of the CASB to investigate ATS occurrences by creating new controller positions for the investigation and analysis of ATS occurrences.
- Developing improved standards for the consistent collection and recording of data relating to ATS occurrences, regardless of whether the CASB or Transport Canada investigates the occurrence.
- Requiring that final reports on ATS occurrences investigated by Transport Canada are formally monitored by the CASB.

Progress on these initiatives should be reported to Parliament in the CASB's (or its successor's) Annual Reports.

- THE END -

GLOSSARY

ACARS	Airlines Communications Addressing and Reporting
ACC	Area Control Centre
ADS	Automatic Dependent Surveillance
AGCS	Air Ground Communications Systems
AGL	Above Ground Level
AI	Air Traffic Controller
ANO	Air Navigation Order
ARTCC	Air Route Traffic Control Centre
ASDE	Airport Surface Detection Equipment
ASL	Above Sea Level
ASRS	Aviation Safety Reporting System
ATAC	Air Transport Association of Canada
ATC	Air Traffic Control
ATCOH	Air Traffic Control Occupational Health Program
ATIS	Air Traffic Information Service
ATS	Air Traffic Services
ATSD	Air Traffic Service Directive
CAATS	Canadian Automated Air Traffic System
CADORS	Civil Aviation Daily Occurrence Reporting System
CAI	Canadian Airlines International
CAIDS	Canadian Accident/Incident Data System
CALPA	Canadian Airline Pilots Association
CAR	Canadian Airspace Review
CASB	Canadian Aviation Safety Board

GLOSSARY

CASP	Canadian Airspace Systems Plan
CASRP	Confidential Aviation Safety Reporting Program
CATCA	Canadian Air Traffic Controllers Association
CBAA	Canadian Business Aircraft Association
CCWS	Common Controller Work Stations
CMNPSA	Canadian Minimum Navigation Performance Specification Airspace
CNS	Communications, Navigation and Surveillance
COPA	Canadian Owners and Pilots Association
CVFR	Controlled Visual Flight Rules
DCPC	Direct Controller/Pilot Communications
DF	Direction Finding
DME	Distance-Measuring Equipment
DND	Department of National Defence
DSC	Data Systems Coordinator
ETOPS	Extended Range Twin-Engined Operations
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FFB	Fact Finding Board
FIR	Flight Information Region
FL	Flight Level
FSS	Flight Service Station
FY	Fiscal Year
GAATS	Gander Automated Air Traffic System
GAMPS	Gander Automated Message Processing System
GAO	General Accounting Office (U.S.)
GPS	Global Positioning System

GLOSSARY

HF	High Frequency
ICAO	International Civil Aviation Organization
ICCS	Integrated Communications Control System
IFALPA	International Federation of Airline Pilots Association
IFR	Instrument Flight Rules
IFSS	International Flight Service Station
ILS	Instrument Landing System
IM	Indicator Module
IMC	Instrument Meteorological Conditions
JETS	Joint Enroute Terminal System
KVT	Knowledge Verification Test
LBPIA	Lester B. Pearson International Airport
MACCO	Managers of ACC Operation
MANOPS	Manual of Operations
MCAT	Multiple Controller Aptitude Test
MLS	Microwave Landing System
MNPS	Minimum Navigation Performance Specification
MTOW	Maximum Take-off Weight
MYOP	Multi-Year Operation Plan
NACS	Northern Airspace Control System
NASA	National Aeronautics and Space Administration (U.S.)
NAT/SPG	North Atlantic Special Planning Group
NAT MNPSA	North Atlantic Minimum Navigation Performance Specifications
NATS	National Air Traffic Control Simulator
NAVSTAR	Navigation Satellite
NDB	Non-directional Beacon

GLOSSARY

NFDS	National Flight Data Processing System
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (U.S.)
OCR	Operational Condition Report
OIDS	Operational Informational Display System
OJB	On-the-job Training
OJI	On-the-job Instruction
OSS	Operational Support Staff
PAL	PeripherAL
PIP	Phraseology Improvement Program
PRAP	Proficiency Review and Assessment of Potential
PY	Person-Year
R/T	radio telephone
RAMP	Radar Modernisation Project
RAP	Resource Alignment Project
RDPS	Radar Data Processing System
RNAV	Area Navigation
SAE	Society of Automotive Engineers
SELCAL	Selective Calling
SID	Standard Instrument Departure
SSR	Secondary Surveillance Radar
STAR	Standard Arrival Route
TC	Transport Canada
TCAS	Traffic Alert and Collision Avoidance System
TCTI	Transport Canada Training Institute
TCU	Terminal Control Unit

GLOSSARY

TRACON	Terminal Radar Approach Control
TRSA	Terminal Radar Service Areas
UHF	Ultra High Frequency
USA	United State of America
VFR	Visual Flight Rules
VHF	Very High Frequency
VIP	Visual Information Presentation
VLF	Very Low Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Radio